Overview of Water Use and Transfer in the Chicopee River Basin

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Executive Summary

Introduction

This study was funded by the Executive Office of Environmental Affairs (EOEA), through the Massachusetts Watershed Initiative and managed by the Massachusetts Department of Environmental Management (MDEM), now the Massachusetts Department of Conservation and Recreation (MDCR) to evaluate seasonal water movement and use within the Chicopee River basin.

Located in central Massachusetts, the Chicopee River basin is surrounded by the Connecticut, Millers, Nashua, Blackstone, French, and Quinebaug River basins. The Chicopee River basin drains approximately 722 mi^2 and is comprised of three major watersheds-the Swift River, Ware River, and Quaboag River watersheds. Quabbin Reservoir, located in the Swift River watershed of the Chicopee, is one of the largest reservoirs constructed for public water supply in the world. It is the primary water supply source for most of the cities and towns near metropolitan Boston. The resulting wastewater is treated and discharged into Boston Harbor, many miles from its original source. The Chicopee River basin also contains several dams and is the site of many other withdrawals and diversions. Interbasin transfers and diversions can cause major reductions in streamflow.

The objective of this study was to evaluate streamflows, precipitation, water withdrawals, wastewater discharges, and interbasin water transfers to quantify and describe water movement within the Chicopee River basin. Emphasis was placed on evaluating 2001 water data, since water supply reports and other water reports were readily available for that period. A large component of this study also included the development of an interactive Geographic Information System (GIS), which catalogued the data collected as part of the study.

Summary of Key Study Findings and Results

Swift River Watershed

Water users withdrew approximately 80,771 million gallons (MG) in 2001 within the Swift River watershed. This accounted for 91.5 percent of the total water withdrawn from the Chicopee River basin. Water withdrawal and transfer patterns in the Swift River watershed are generally controlled by the Massachusetts Water Resources Authority (MWRA). The MWRA withdrawals accounted for approximately 79,119 MG (217 MGD) or 98 percent of the total water withdrawn from the Swift River watershed. The McLaughlin State Fish Hatchery was second accounting for 1,518 MG (4.2 MGD) or 1.9 percent of the total water withdrawn, while the Belchertown 40 MG (0.11 MGD) and Bondsville 94 MG (0.26 MGD) water districts combined for less than 1 percent. Water withdrawals made by the MWRA account for a significant portion of the water withdrawn not only from the Swift River watershed but the entire Chicopee River basin.

In 2001, all the water withdrawn by the MWRA was transferred out of the Chicopee River basin. This water was transferred either through the Quabbin Aqueduct (78 percent of total) to provide metropolitan Boston with drinking water, or through the Chicopee Valley Aqueduct (22 percent of total) to the Connecticut River basin to provide water for the towns of South Hadley, Wilbraham, and Chicopee. Peak water transfers for both aqueducts occurred during the late summer and fall months.

Bondsville Water District transferred 44.6 MG (0.12 MGD) of its total withdrawals from the Swift River watershed to the Thorndike Water District located within the Ware River watershed in 2001. This

monthly transfer of water was similar throughout the year with quantities ranging from 2.9 MG (0.11 MGD) in February to 4.6 MG (0.15 MGD) in July.

As part of the MWRA operations in 2001, 4,112 MG (11.3 MGD) was transferred from the Ware River watershed to the Quabbin Reservoir (Swift River watershed) during the month of April to supplement withdrawals from the Chicopee Valley and Quabbin Aqueducts.

In 2001, Belchertown Water District pumped just under 64.5 MG (0.18 MGD) from the Connecticut River basin to the Swift River watershed.

Streamflows in the Swift River watershed have been affected the most by water withdrawals and inter-basin transfers. The amount of water transferred from the Swift River watershed during 2001 was substantially greater than the streamflow volume measured in the Swift River for every month, except April. The diversion of this water from Quabbin Reservoir results in alterations to the timing and magnitude of flows within the Swift River watershed.

MWRA is required to release a minimum flow of 20 MGD (32 cfs) from Quabbin Reservoir to the Swift River. The beneficial effect of providing this water from storage was evident during October and November of 2001, when precipitation totals in the Chicopee basin were well below normal. During those months, flows on the Ware and Quaboag Rivers were well below normal as well. However, during this period flows on the Swift River were near normal levels due to the minimum flow release from storage.

Ware River Watershed

A total of seven registered water users withdrew approximately 6,303 MG (17.3 MGD) of water from the Ware River watershed in 2001, which accounted for 7.1 percent of the water withdrawn from the Chicopee River basin. Water withdrawn by the MWRA totaled 4,112 MG (11.3 MGD) and accounted for 65 percent of the water withdrawn from the Ware River watershed. This large withdrawal only occurred during the month of April, when water was transferred to the Quabbin Reservoir (Swift River watershed). Water withdrawals by Fitchburg Water Department totaled 1,341 MG (3.7 MGD) or 21.3 percent of the total. The remaining five water users withdrew 850 MG (2.3 MGD) and accounted for the remaining 13.5 percent. Peak water demand occurred during August and September, and the lowest demand was in January.

All of the water (1,341 MG) withdrawn by Fitchburg Water Department is transferred to the Nashua River basin. Peak demand generally occurred from August through December with just over 71 percent of the water being transferred during these months.

As mentioned previously, the MWRA transferred water (4,112 MG) from the Ware River to the Quabbin Reservoir (Swift River watershed) and the Thorndike Water District (Ware River watershed) imported water (44.6 MG) from the Bondsville Water District (Swift River watershed). Importation of water took place throughout 2001 with the peak demand occurring during the summer months.

The Ware River watershed is impacted much less by water withdrawals and diversions compared to the Swift River watershed. However, from September to November of 2001, out-of-basin transfers were moderately high relative to average monthly streamflow in the watershed. This was partly driven by unusually low streamflow resulting from lower than normal precipitation totals.

Quaboag River Watershed

In 2001, eleven registered water users withdrew just over 1,223 MG (3.4 MGD) of water from the Quaboag River watershed, which accounted for only 1.4 percent of the total water withdrawn from the Chicopee River basin. Water withdrawn by the Spencer Water Department totaled 270 MG (0.74 MGD) and accounted for 22 percent of the water withdrawn from the Quaboag River watershed. Monson Water and Sewer was second at 191 MG (0.52 MGD) or 15.6 percent, and North Brookfield was third at 160 MG (0.44 MGD) or 13.1 percent. Peak water withdrawals occurred during May and June, while the least amount of water was withdrawn during the winter months.

Unlike the Swift and Ware River watersheds that experience transfers of water both within the basin and out of the basin, no such transfers of water occur in the Quaboag River watershed. Due to the low precipitation conditions experienced in the latter portion of 2001, in-basin water withdrawals were marginally high compared to the average monthly streamflow for August, September, and October.

Conclusions

Streamflow in the Swift River watershed has been significantly affected by water withdrawals and inter-basin transfers, resulting from Quabbin Reservoir operation. In 2001, the out-of-basin transfers of 217 MGD from Quabbin Reservoir were substantially greater than the streamflow volume measured in the Swift River. This diversion of water from Quabbin Reservoir results in alterations to the timing and magnitude of flows within the Swift River watershed, which may result in adverse impacts to downstream aquatic biota. Alterations in flow are particularly evident during the typical spring high flow period, when flows are drastically reduced in the Swift River because of flood skimming and water storage operations at Quabbin.

MWRA is required to release a minimum flow of 20 MGD (32 cfs) from Quabbin Reservoir to the Swift River. This flow release has beneficial effects such as maintaining Swift River flows, during the late summer/early fall of 2001, near normal regulated levels at times of extended low precipitation. At the Ware and Quaboag Rivers, which do not benefit from summer/fall flow augmentation, streamflows are directly tied to the prevailing precipitation levels, and as a result were much lower than historic averages during the late summer/early fall of 2001.

The Ware and Quaboag River watersheds are impacted much less by water withdrawals and diversions compared to the Swift River watershed. However, from September to November of 2001, water withdrawals were relatively high compared to average monthly streamflow in the watersheds. This was partly attributable to lower than normal precipitation levels.

It is unclear whether the interaction between water withdrawals, streamflow patterns, and water movement is consistent from year to year, since the evaluation of water withdrawals within this study was focused on the year 2001, which experienced below normal annual precipitation levels. A longer study period would have been representative of more typical hydrologic conditions.

A definitive analysis of consumptive water use within the Chicopee River basin was not fully evaluated, since the study contained only a cursory review of NPDES wastewater discharges, as the study scope did not allow for an exhaustive data collection and evaluation effort.

Study Recommendations

The following recommendations to improve management of water movement and use are based on the conclusions of this study.

- Evaluate alternative schedules for minimum flow releases from Quabbin Reservoir to the Swift River to mimic natural flow patterns to the greatest extent possible. The operation of Quabbin Reservoir significantly alters the timing and magnitude of streamflow in the Swift River. It may be possible to minimize the potential impact of these water withdrawals on downstream aquatic biota through alternative reservoir management practices.

- Future investigations should encompass a five year evaluation period of the interaction between water withdrawals, streamflow patterns, and the corresponding movement of water within the Chicopee basin. The evaluation of water withdrawals within this study was focused on the year 2001, which represented atypically dry hydrologic conditions. A longer study period would be more representative of average hydrologic conditions.

- Future investigations should include a more detailed inflow/outflow analysis to assess monthly water balances within each watershed. The study examined water withdrawal volumes in detail; however, limitations in the scope did not allow for an in-depth analysis of consumptive water use in the Chicopee basin.

- The interactive Geographic Information System (GIS) should be updated periodically with new data as it becomes available. A significant portion of this study included the development of an interactive GIS, which contained the data collected as part of this study. It is envisioned that the GIS will assist those, who manage the water resources within the Chicopee River basin, as well as those who wish to understand water movement and use in the basin.

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Acronyms and Conversions

ABF	Aquatic Base Flow
cfs	cubic feet per second
cfsm	cubic feet per second per square mile of drainage area
EOEA	Executive Office of Environmental Affairs
GIS	Geographic Information System
GPD	gallons per day
MassGIS	Massachusetts Geographic Information System
MDCR	Massachusetts Department of Conservation and Recreation
MDEM	Massachusetts Department of Environmental Management
MDEP	Massachusetts Department of Environmental Protection
MDFW	Massachusetts Department of Fisheries and Wildlife
MG	million gallons
MGD	million gallons per day
MGM	million gallons per month
MGY	million gallons per year
MSL	mean sea level
MWRA	Massachusetts Water Resources Authority
NPDES	National Pollutant Discharge Elimination System
PWSASR	Public Water Supply Annual Statistical Report
USGS	United States Geological Survey
WMA	Water Management Act

Conversions

1 MGD=1.547 cfs
1 acre= 43,560 square feet
1 mi2= 640 acres

1 Introduction

This study was funded by the Executive Office of Environmental Affairs (EOEA), through the Massachusetts Watershed Initiative and managed by the Massachusetts Department of Environmental Management (MDEM), now the Massachusetts Department of Conservation and Recreation (MDCR) to evaluate seasonal water movement and use within the Chicopee River basin[1].

Quabbin Reservoir, located in the Swift River watershed of the Chicopee, is one of the largest reservoirs constructed for public water supply in the world. It is the primary water supply source for most of the cities and towns within 15 miles of Boston. Water is diverted from Quabbin Reservoir to both the Wachusett Reservoir and the Chicopee Aqueduct. The Chicopee River basin contains many dams and is the site of many diversions. Interbasin transfers such as Quabbin Reservoir are common in Massachusetts as up to 230 MGD of water is transported east from watersheds in central Massachusetts. The resulting wastewater is collected, treated and discharged in the Boston Harbor, many miles from its original source. These interbasin transfers and other diversions can cause major reductions in streamflow, particularly in the summer, when large volumes of water are removed from the Chicopee River basin.

The objective of this study is to evaluate streamflows, precipitation, water withdrawals, wastewater discharges and interbasin water transfers to quantify and describe water movement within the Chicopee River basin and its watersheds. Described below are the hydrologic parameters that were investigated to understand water movement in the Chicopee River basin.

- Three long-term precipitation gages dispersed throughout the basin were chosen for analysis. Precipitation data were used to create a series of graphics to reflect both the annual and seasonal variability of rainfall for 2001 and the entire period of record.

- Streamflow data was obtained from four United States Geological Survey (USGS) gages within the Chicopee basin. The gages were located in the lowermost portion of each major watershed (Swift, Ware, and Quaboag) and have long periods of record that reflect regulated flow conditions. The gages are not a measure of basin inflow but reflect the result of human activities such as interbasin transfers and water diversions. These data were used to create a series of graphics to reflect the annual and seasonal availability of water within each watershed for 2001 and the entire period of record.

- Water withdrawal information was gathered from water users in the Chicopee basin that are registered under the Water Management Act (WMA). In 2001, there were 17 water suppliers, three industrial users, and two fish hatcheries withdrawing a daily average of more than 100,000 gallons per day (GPD) from the Chicopee basin. Data was used to create a series of graphics to identify annual and monthly water demands in each of the three major watersheds (Swift, Ware, and Quaboag) within the Chicopee River basin in 2001. In addition, the analysis was extended to evaluate water withdrawn from a watershed, but diverted to a different watershed in the Chicopee basin, and water withdrawn from a watershed but diverted out of the Chicopee basin. To gain a better understanding of water movement within the Chicopee basin, water withdrawals and transfers were also evaluated on a subwatershed scale for each of the three watersheds as well.

[1] For the purposes of this report, the entire study area will be referred to as the Chicopee River basin. Drainage areas of the Swift, Ware, and Quaboag Rivers, which comprise the Chicopee River basin, will be referred to as watersheds. Drainage areas within each of these three major watersheds will be referred to as subwatersheds.

- National Pollutant Discharge Elimination System (NPDES) dischargers act as another type of water diversion. Water withdrawn from a watershed is sometimes discharged outside the watershed or the Chicopee basin entirely. Permitted dischargers either located in the Chicopee basin or discharging effluent into the water located within the basin were identified to determine the annual magnitude of discharges.

A large component of this study also included the development of an interactive Geographic Information System (GIS). The GIS was developed to summarize the findings of this study and many of the tables and figures appearing in this report were incorporated into the GIS.

In this study, emphasis was placed on evaluating 2001 water data. This year was selected since it is the most recent in which water supply reports and other water reports were readily available. In cases where long-term water resource data was available, such as USGS flow gages, the full period of record was evaluated in addition to 2001.

2 Chicopee River Basin Description and Land Use Characteristics

2.1 Overview of the Chicopee Basin

Located in central Massachusetts, the Chicopee basin is surrounded by the Connecticut, Millers, Nashua, Blackstone, French, and Quinebaug River basins (see Figure 2.1-1). The Chicopee River basin drains approximately 722 mi^2 and is comprised of three major watersheds, which are further divided into 48 subwatersheds.

The mainstem Chicopee River originates in Palmer, MA at the confluence of the Ware and Quaboag Rivers and flows west just over 17 miles to the town of Chicopee where it empties into the Connecticut River. The three main tributaries of the Chicopee include the Swift, Ware, and Quaboag Rivers as shown in Figure 2.1-2. The Swift River serves as the major outflow for Quabbin Reservoir, and drains four subwatersheds encompassing approximately 215 mi^2. It flows south 8.7 miles to the town of Three Rivers where it empties into the Ware River.

The East and West Branches of the Ware River combine at the Barre Falls Dam Project in the northeast portion of the Chicopee River basin to form the mainstem Ware River. The Ware River flows 34 miles, includes 17 subwatersheds and drains approximately 217 mi^2 before joining the Quaboag River near the town of Three Rivers.

The Quaboag River originates at Quaboag Pond near the town of Brookfield and has a drainage area of 212 mi^2, including 18 subwatersheds. It flows approximately 25 miles west where it combines with the Ware River to form the Chicopee River.

The Chicopee basin contains a plethora of water resources with over 174 lakes, ponds, and impoundments. A total of 103 dams (Mass-GIS) are scattered throughout the basin. Most of the dams are small in scale, however, some of the larger dams associated with water supply reservoirs, and hydroelectric facilities greatly alter the flow regime throughout the basin. Quabbin Reservoir, the largest of the water supply reservoirs, covers 24,700 acres and is one of the largest reservoirs constructed for use as a public water supply in the world. The Quabbin Reservoir is also part of the largest interbasin transfer of drinking water in the state. Water transfers from the Quabbin Reservoir provide much of the drinking water for metropolitan Boston.

In 2001, there were 22 water users registered under the WMA that cumulatively withdrew nearly 88.3 billion gallons of water from the Chicopee River basin. This is equivalent to an average annual flow of 387 cfs. Also in 2001, there were 15 registered National Pollutant Discharge Elimination Systems (NPDES) operating within the basin. Some of these discharge systems act as another form of water diversion, discharging water away from the original source and into another watershed or outside the Chicopee basin entirely. Due to the high demand on water resources, streamflow issues and interbasin transfers are a major concern within the Chicopee basin. Much of the water withdrawn from the Chicopee basin is transferred out of the basin and discharged many miles from its original source.

2.2 Land Use in the Chicopee River Basin

1999 mapping data from Mass-GIS was analyzed to estimate land use in the Chicopee River basin. Table 2.2-1 shows the land use definitions included in the mapping data, and the portion of the Chicopee basin comprised of each land type. Figure 2.2-1 illustrates where in the Chicopee basin each of the land use types occur.

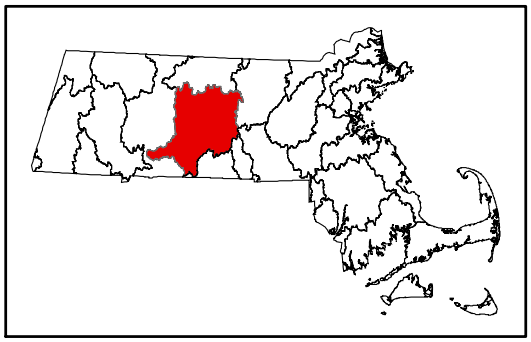
Table 2.2-1: Land Uses in the Chicopee River Basin

Category	Definition	Percent of Basin
Cropland	Intensive agriculture	4.6%
Pasture	Extensive agriculture	2.5%
Forest	Forest	69.1%
Wetland	Nonforested freshwater wetland	2.3%
Mining	Sand; gravel & rock	0.3%
Open Land	Abandoned agriculture; power lines; areas of no vegetation	2.3%
Recreation	Includes participation, spectator and water based recreation	0.5%
Residential	Multi-family, and lots < ¼ acre and > than ½ acre	8.6%
Saltwater Wetlands	Salt marsh	0.0%
Commercial	General urban; shopping center	0.3%
Industrial	Light & heavy industry	0.5%
Urban Open	Parks; cemeteries; public & institutional greenspace	0.7%
Transportation	Airports; docks; divided highway; freight; storage; railroads	0.6%
Waste Disposal	Landfills; sewage lagoons	0.1%
Water	Fresh water; coastal embayment	7.2%
Woody Perennial	Orchard; nursery; cranberry bog	0.3%

Based on the 1999 land use mapping data, approximately 70 percent of the Chicopee River basin is forested while residential development accounts for the second largest land use category at approximately 9 percent. Agricultural uses and water each accounted for approximately 7 percent.

The basin includes all or portions of 39 municipalities that support just under 430,000 (2000 census) people. The major population centers include the municipalities of Ludlow, Chicopee, and Springfield, which are located in the southwest portion of the basin around the mainstem of the Chicopee River.

General Locale of the Chicopee River Basin



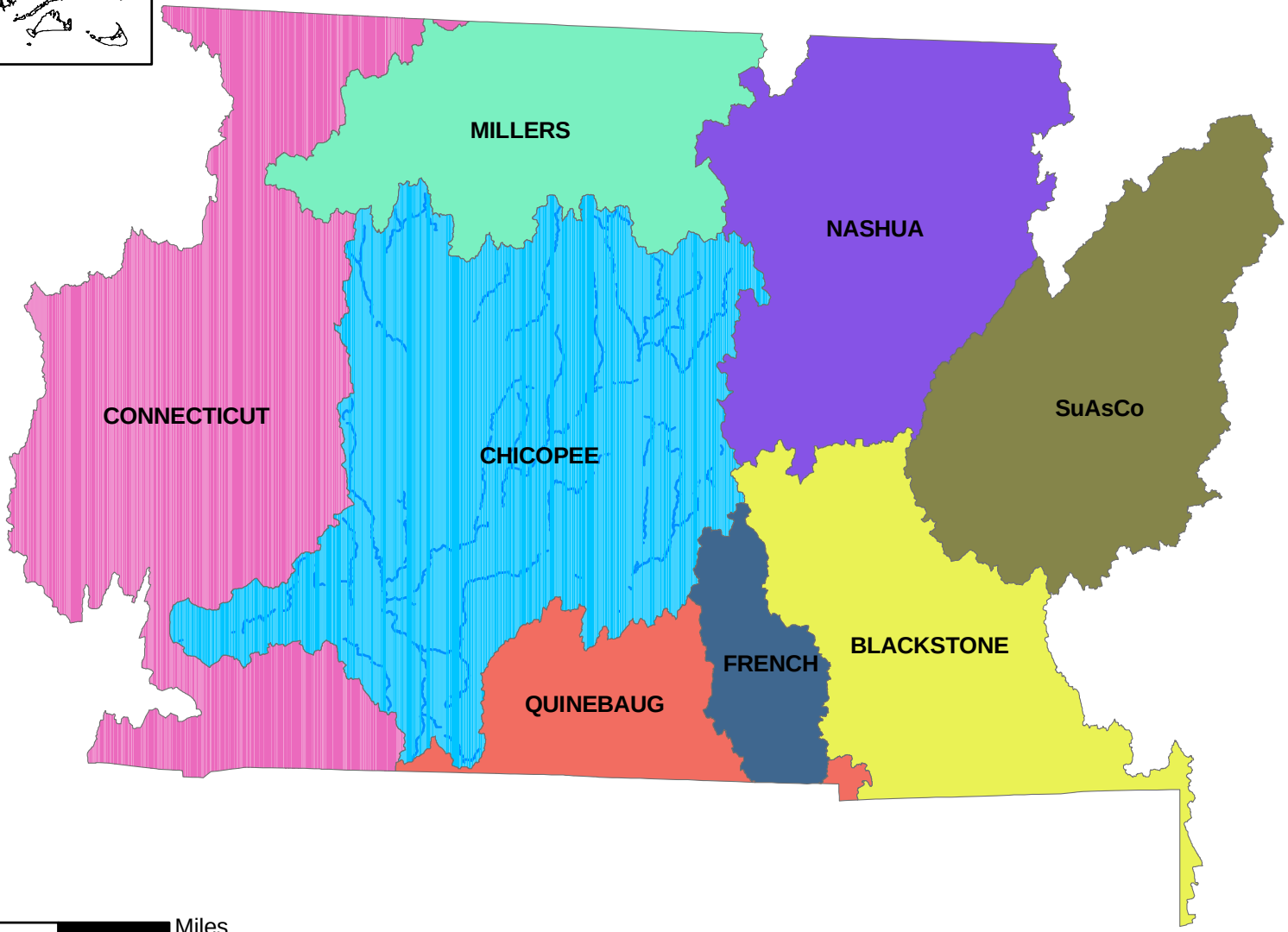
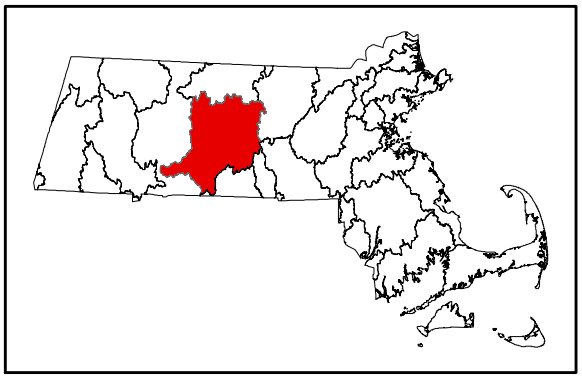


Figure 2.1-1

Major Watersheds within the Chicopee River Basin



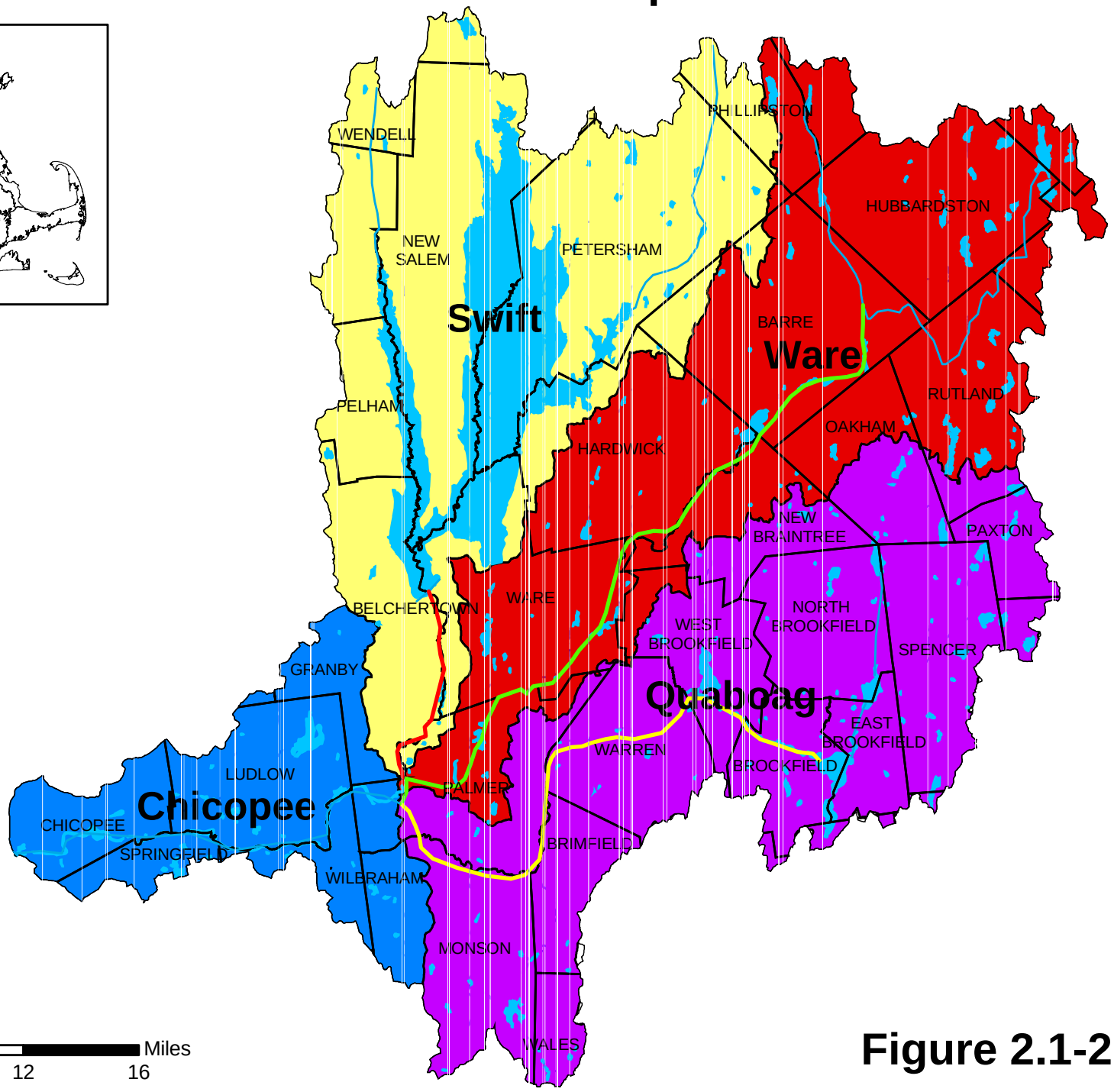
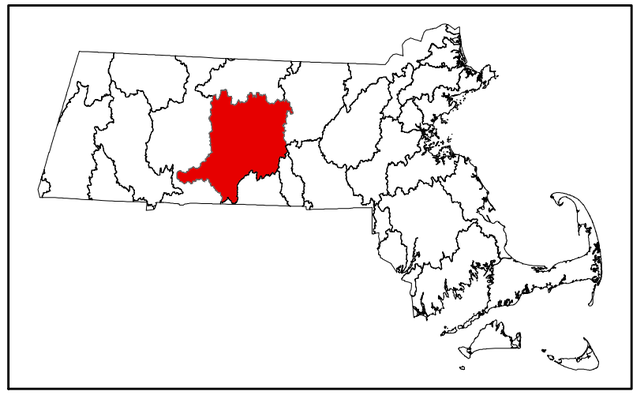
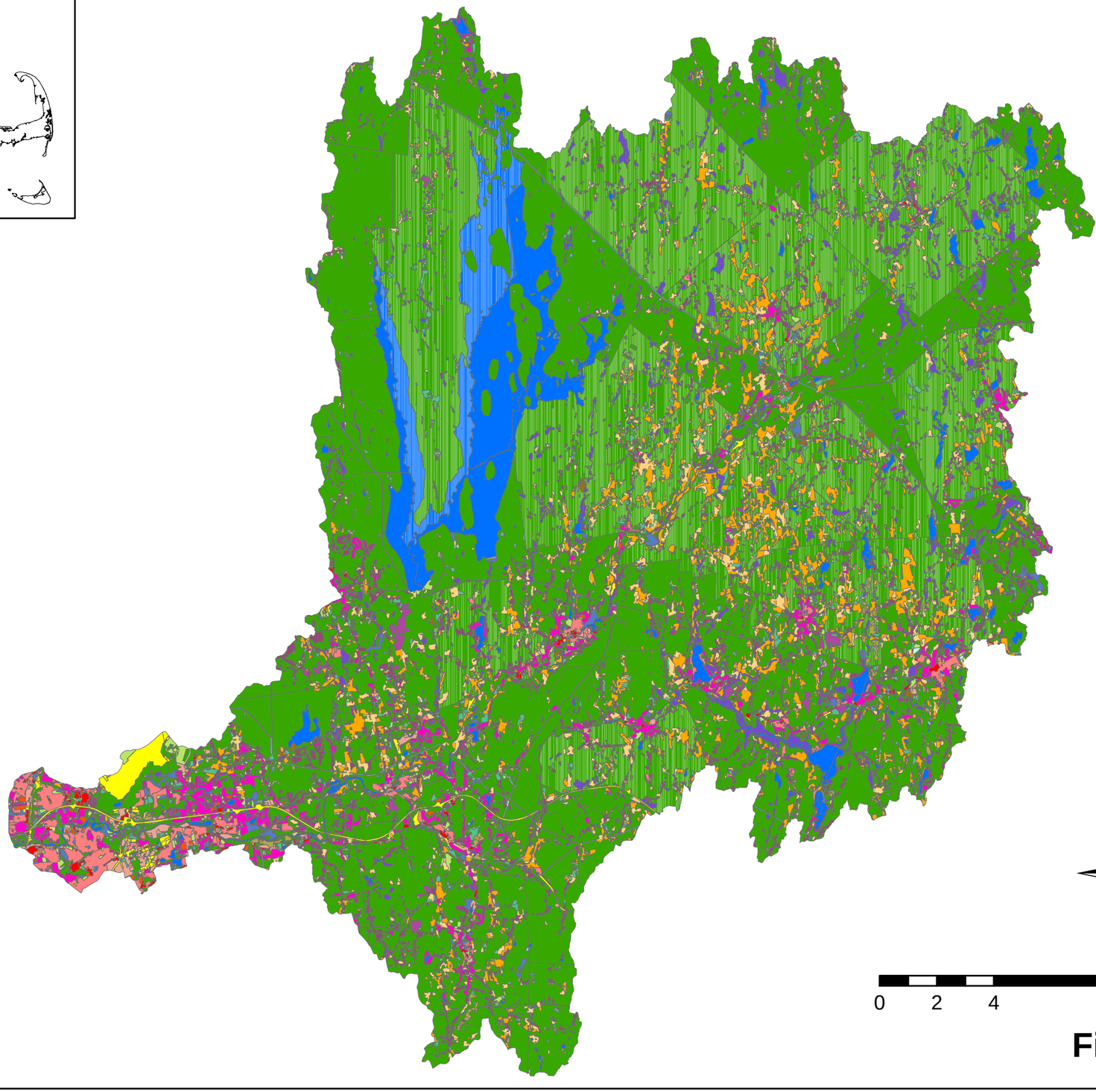


Figure 2.1-2

Land Use within the Chicopee River Basin (1999)





Legend

Chicopee Landuse

- Cropland
- Pasture
- Forest
- Wetland
- Mining
- Open Land
- Participation Recreation
- Spectator Recreation
- Water Based Recreation
- Residential (Multi-Family)
- Residential (< 1/4 acre lots
- Residential (1/4 to 1/2 acre lots)
- Residential (> 1/2 acre lots)
- Commercial
- Industrial
- Urban Open
- Transportation
- Waste Disposal
- Water
- Woody Perennial

N

0 2 4 8 12 16 Miles

Figure 2.2-1

3 Evaluation of Precipitation

The following section investigates precipitation data recorded at three stations throughout the Chicopee River basin. The purpose for evaluating the precipitation data is to put into perspective the 2001 annual precipitation relative to the period of record. In addition, analyzing the precipitation data will provide a sense of potential streamflow conditions, absent the effect of human disturbances.

3.1 Available Precipitation Data

MDEM identified 19 precipitation gages within the Chicopee River basin that report the Massachusetts rainfall monitoring program, some of which have a period of record beginning in the late 1800's. Table 3.1-1 list all the gages located in the Chicopee River basin, their period of record, and activity status. Three precipitation gages (shaded in Table 3.1-1 and shown in Figure 3.1-1) were selected based on: a) adequate spatial distribution throughout the basin, b) the period of record was greater than 60 years, and c) complete monthly data was available for 2001.

Table 3.1-1: Active and Retired Precipitation Gages in the Chicopee River Basin

Gage ID	Gage Name	Starting Period	Ending Period	Active
BAR416	Barre (Cold Brook)	1930	2003	Yes
BARCOE	Barre Falls Dam	1984	2003	Yes
BEL314	Belchertown	1939	2003	Yes
CHI306	Chicopee SP	1997	2003	Yes
HAR420	Hardwick	1920	2003	Yes
HAR421	Hardwick	1942	2003	Yes
LUD318	Ludlow	1875	2003	Yes
MON323	Monson	1885	2003	Yes
NEW422	New Braintree	1929	2003	Yes
NEW308	New Salem (N)	1941	2003	Yes
NEW311	New Salem (S)	1919	2003	No
PAL319	Palmer	1921	2003	Yes
PET409	Petersham	1939	2003	Yes
RUT417	Rutland (W)	1927	2003	Yes
WAR315	Ware	1919	2003	Yes
WARNWS	Ware	1992	2003	Yes
WAR427	Warren	1911	2003	Yes
WBRNWS	West Brimfield			No
CHINWS	Westover (Chicopee Falls)	1965	2003	Yes

Average annual precipitation in the Chicopee basin is approximately 45 inches per year. Annual precipitation is distributed nearly normally over the months of the year, with monthly normals of 3 to 4 inches. Considering the average annual precipitation in the basin, the potential average recharge is on the order of 1,496 million gallons per day (MGD) or 2,394 cubic feet second (cfs).

3.2 Evaluation of Precipitation Data

To compare 2001 and historical precipitation totals, graphics were developed showing the historical average annual precipitation relative to the 2001 precipitation for the three gages as shown in Figure 3.2-1. Also, to reflect the seasonal availability of precipitation in the basin, average monthly precipitation

was plotted for the period of record and 2001 for all three stations as shown in Figures 3.2-2 through 3.2-4.

Table 3.2-1 depicts the percent normal monthly and annual precipitation for 2001 at all three stations relative to historical conditions. A percent normal value less than 100 corresponds to drier precipitation conditions, and vice versa. For instance, a percent normal value of 83 means that precipitation totals were 83 percent (or 17 percent less than the average) of the long-term average. A percent normal of 100 would represent normal or average precipitation conditions.

Table 3.2-1: Percent Normal Monthly and Annual Precipitation for 2001

Month	Belchertown	Monson	Petersham
January	51	58	47
February	124	111	102
March	173	181	236
April	46	55	40
May	64	83	54
June	160	179	158
July	61	62	79
August	139	79	71
September	88	86	110
October	29	24	29
November	26	29	30
December	80	69	79
Annual	87	85	87

Monthly precipitation totals in 2001 were generally normal or below average at the Monson and Petersham stations except for the months of February, March, and June. During March, the Petersham station recorded over double (236 percent normal) the normal precipitation for that month and the Monson station recorded just under double (181 percent normal) the normal precipitation. June was also a much wetter than average month for both stations, with precipitation totals greatly exceeding the average for both stations. The Belchertown station exhibited a similar trend except in August when precipitation totals for 2001 were 139 percent normal. This above average precipitation for August 2001 was not recorded at the Monson and Petersham stations and may have been the result of isolated thunderstorms. The months of October and November were extremely dry with monthly precipitation at or below 30 percent normal at each station.

2001 was dryer than normal with precipitation totals below the long term average at all three stations. Differences in precipitation between 2001, and the period of record ranged from 5.5 inches at Petersham (87 percent normal) to 6.5 inches at Monson (85 percent normal).

Precipitation Gage Locations in the Chicopee River Basin

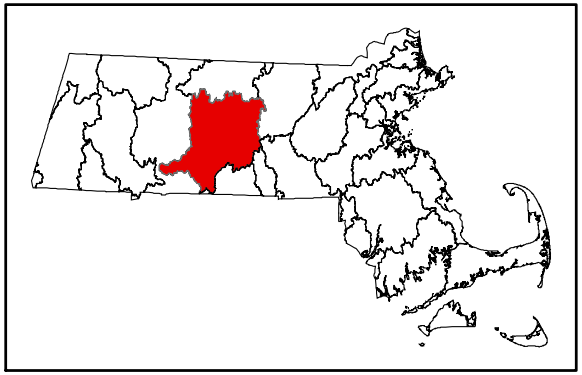


Figure 3.1-1

Figure 3.2-1: Comparison of Average Annual Precipitation for the Period of Record and for 2001 for three Gages in the Chicopee River Basin

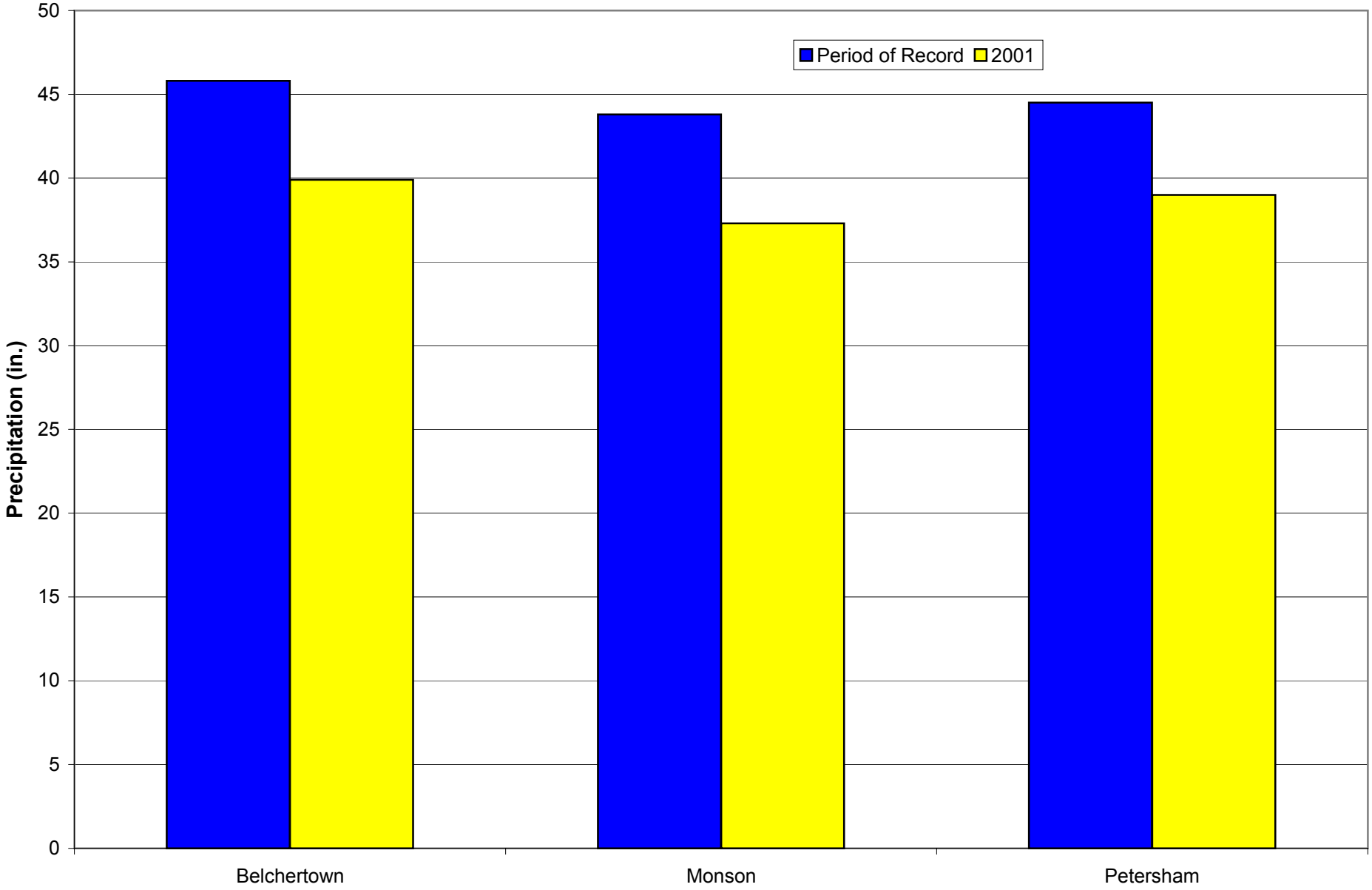


Figure 3.2-2: Comparison of Monthly Precipitation for Period of Record and 2001 at Belchertown Gage

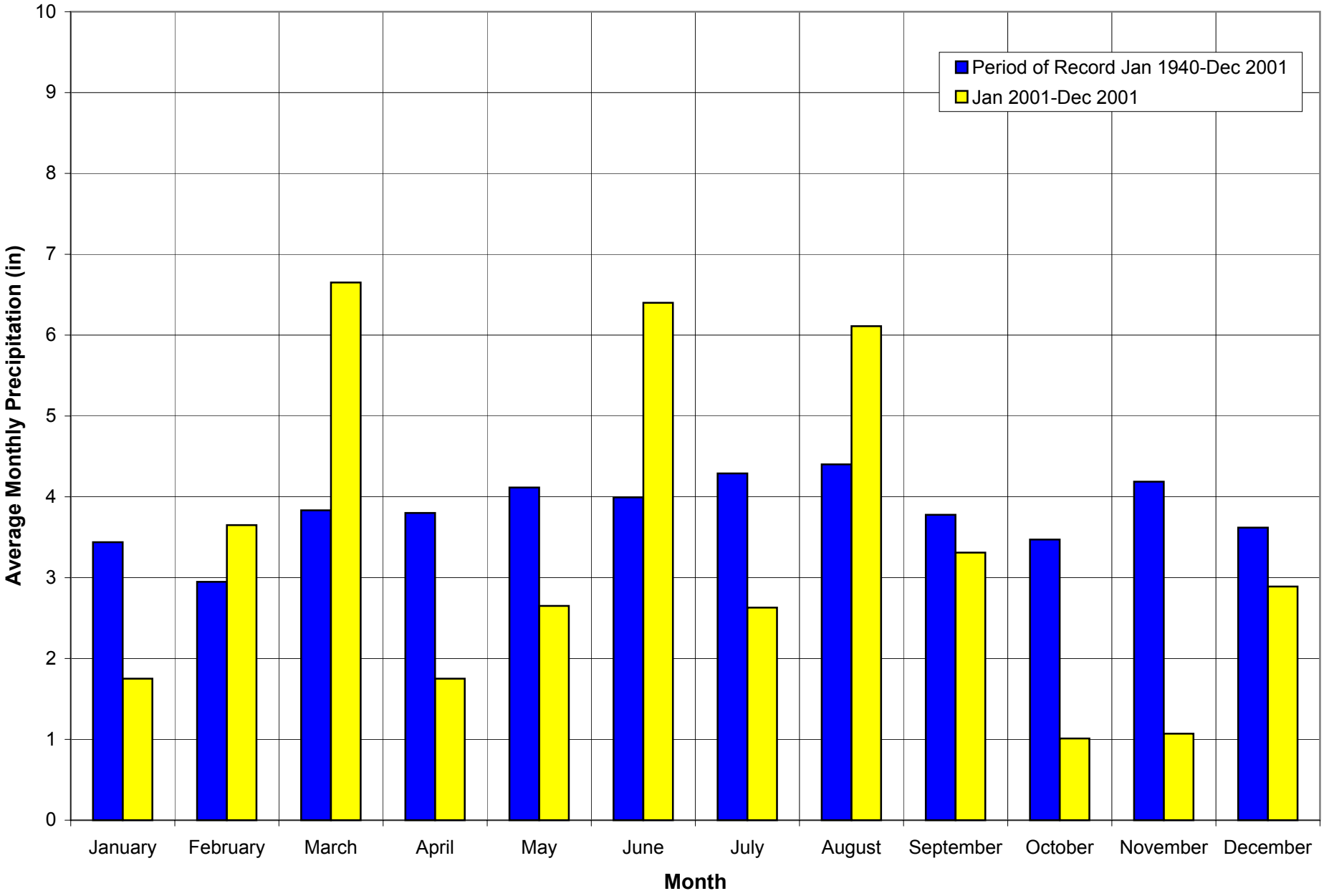


Figure 3.2-3: Comparison of Monthly Precipitation for Period of Record and 2001 at Monson Gage

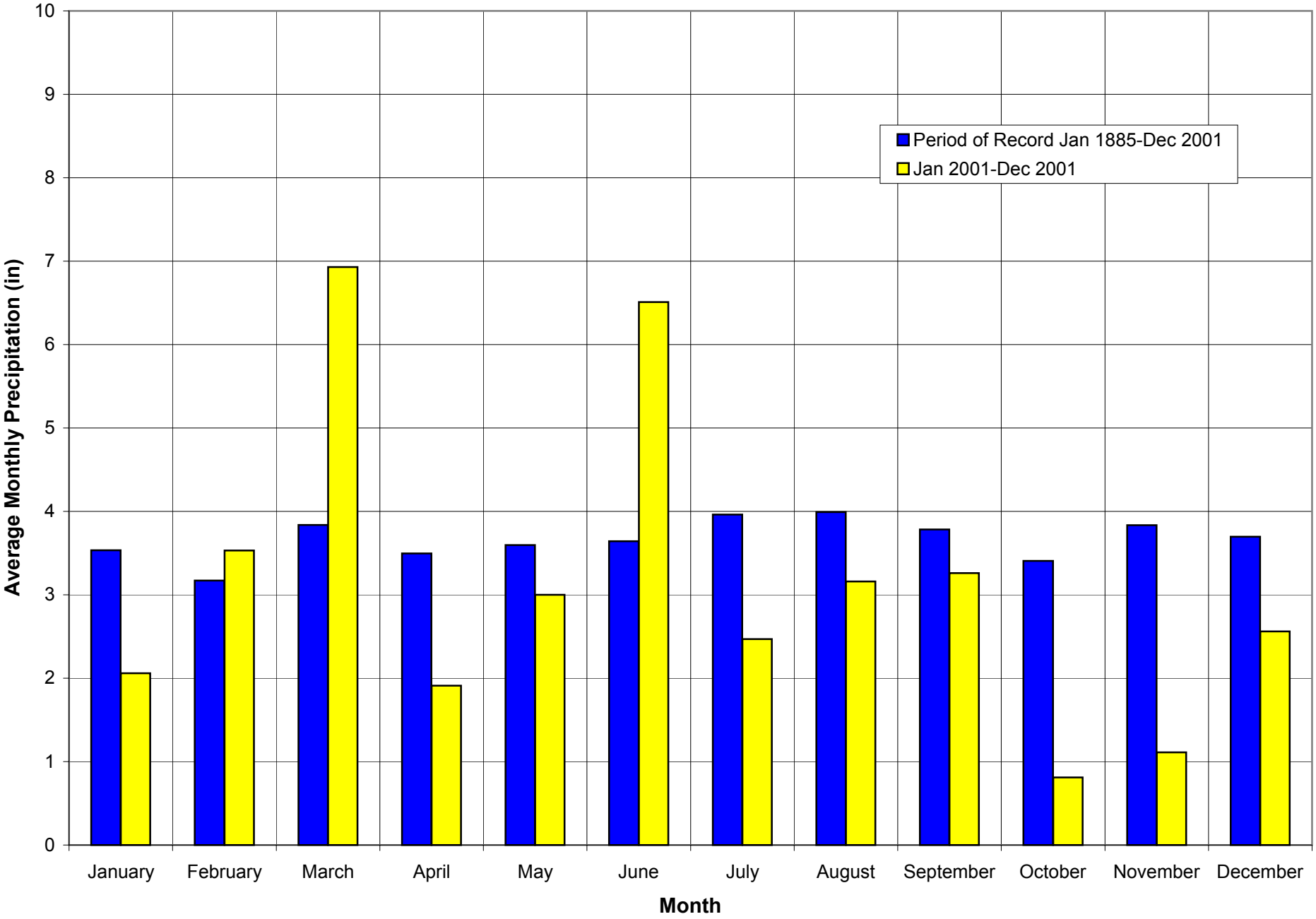
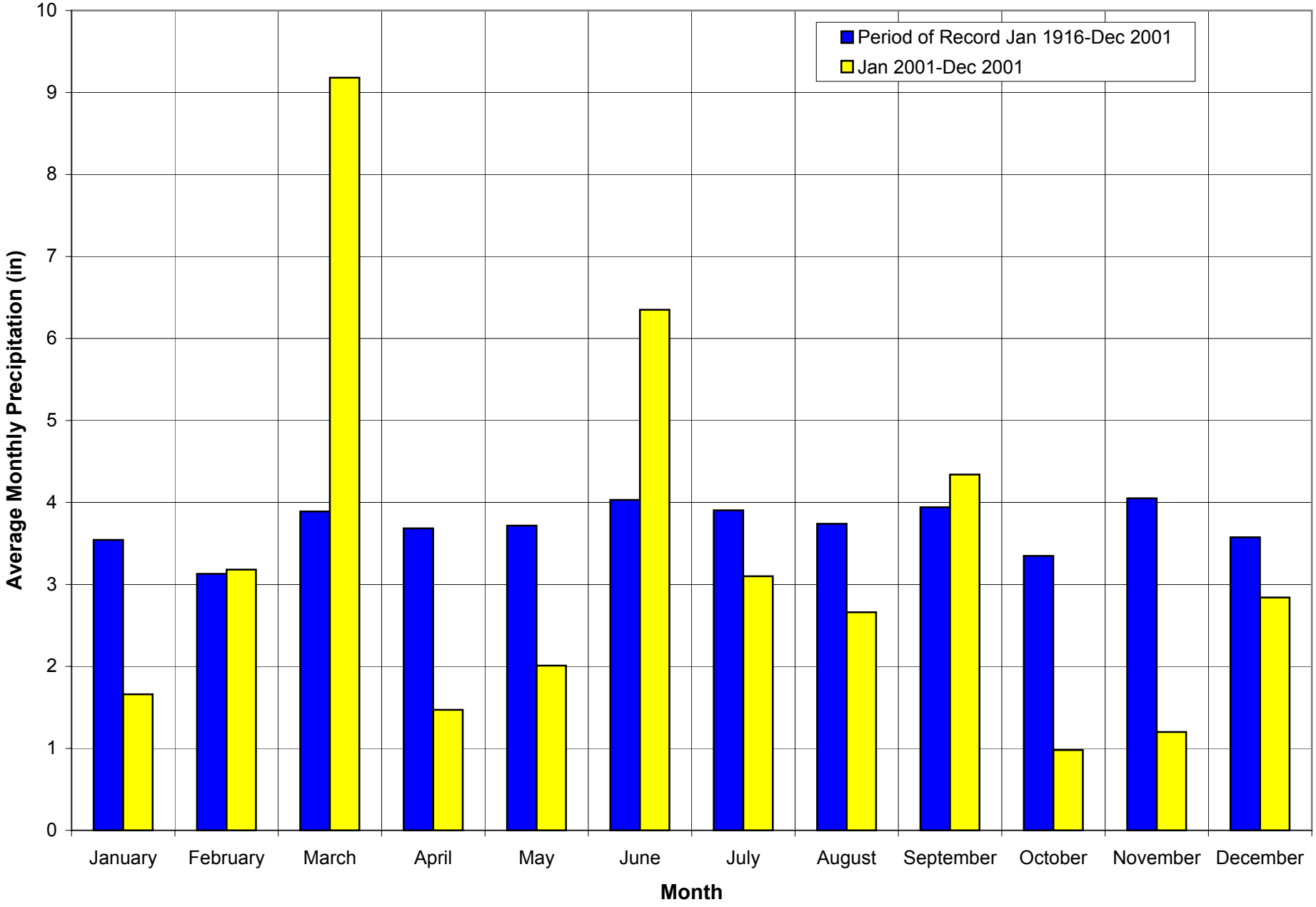


Figure 3.2-4: Comparison of Monthly Precipitation for Period of Record and 2001 at Petersham Gage



4 Evaluation of Streamflow

The purpose of this section is to evaluate existing streamflow data for the major watersheds within the Chicopee River basin.

4.1 Existing Streamflow Data

The USGS operates 18 streamflow gages within the Chicopee River basin, but only nine are active. Table 4.1-1 contains a summary of the active and retired continuously recording streamflow gages within the Chicopee River basin, and the period or record for each gage. For this study, four gages were investigated that monitor flow continuously (shaded in Table 4.1-1 and shown in Figure 4.1-1) and represent each of the three main tributaries and the Chicopee mainstem. Gages were selected based on their location (the Swift, Ware, and Quaboag gages are near the confluence of the Chicopee River) and period of record.

Table 4.1-1: Retired and Active Continuously Recording USGS Gages in the Chicopee River Basin

Station ID	Station Name	Drainage Area (mi^2)	Period of Record
01172500	Ware River near Barre, MA	55.1	07/27/46 to Present
01172680	Natty P Bk Templeton Rd (DS) nr Hubbardston, MA	1.6	10/23/84 to 07/14/88
01172800	Natty Pond Brook near Hubbardston, MA	5.5	11/01/84 to 09/30/88
01173000	Ware River at Intake Works Near Barre, MA	96.3	01/30/28 to Present
01173260	Moose Brook Near Barre, MA	4.6	10/25/62 to 09/30/74
01173500	Ware River at Gibbs Crossing, MA	197.0	08/20/12 to Present
01174000	Hop Brook near New Salem, MA	3.4	11/19/47 to 09/30/82
01174050	East Branch Fever Brook near Petersham, MA	4.9	11/29/83 to 09/30/85
01174500	East Branch Swift River near Hardwick, MA	43.7	01/01/37 to Present
01174565	West Branch Swift River near Shutesbury, MA	12.6	11/08/83 to Present
01174570	Dickey Brook near Cooleyville, MA	1.2	02/12/85 to 09/30/89
01174575	Dickey Brook Tributary near Cooleyville, MA	1.1	02/14/85 to 09/30/89
01174600	Cadwell Creek near Pelham, MA	0.6	07/13/61 to 09/30/94
01174900	Cadwell Creek near Belchertown, MA	2.6	07/13/61 to 09/30/97
01175500	Swift River at West Ware, MA	189.0	10/01/12 to Present
01175670	Seven Mile River near Spencer, MA	8.7	12/01/60 to Present
01176000	Quaboag River at West Brimfield, MA	150.0	08/19/12 to Present
01177000	Chicopee River at Indian Orchard, MA	689.0	08/05/28 to Present

4.2 Evaluation of Streamflow Data

The USGS gages on the Swift, Ware, and Quaboag Rivers all began data collection in 1912, prior to the initiation of Quabbin Reservoir construction in 1936. Construction and filling of Quabbin Reservoir was completed in early 1946. For the period 1946-2001, the USGS streamflow data examined reflect regulated conditions in the basin, which result from human disturbances such as water withdrawals, water diversions, interbasin transfers, and wastewater discharges. All of these anthropogenic effects can influence the timing, duration, magnitude and frequency of flow events relative to a natural or unregulated river system. The principal impact to streamflow in the Chicopee basin is the flow regulation and water withdrawals that result from Quabbin Reservoir. In addition to understanding regulated stream

flow conditions over the past 56 years, we also examined unregulated stream flow conditions during the period from 1912-1935 in the Chicopee, Swift, and Quaboag rivers.

For each of the four gages, the annual and monthly average flow was computed for the 1946-2001 period, 1912-1935 period (not done for the Chicopee River USGS gage operation began in 1928), and 2001 as shown in Figures 4.2-1 through 4.2-5 (Swift, Ware, Quaboag, and Chicopee). Shown in Table 4.2-1 is the average annual and monthly flow (cfs and cfs/mi^2) for the 1946-2001 period, 1912-1935 period (not done for the Chicopee River USGS gage operation began in 1928), and 2001.

The 2001 average annual flow was below the period of record averages at all four stations evaluated. The Quaboag River gage recorded the highest average flow per square mile over the 1946-2001, and during the 1912-1935 periods and in 2001, the flow (cfs/mi^2) was only slightly less than the Ware River station. The Swift River showed the greatest decline in average flow relative to the Quaboag and Ware Rivers. The lower cfsm ratios for the Swift River are a function of Quabbin Reservoir as a larger portion of the watershed yield is diverted out of the basin. The average flow (cfs/mi^2) for the 1946-2001 period is nearly three times less compared to the 1912-1935 period. At both the Ware and Quaboag Rivers, the average flow (cfs/mi) for 1946-2001 and 1912-1935 periods are comparable.

Table 4.2-1: Average Annual and Monthly Flows on the Chicopee, Ware, Swift and Quaboag Rivers

Gage	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
Chicopee River at Indian Orchard													
1946-2001,cfs	967	1,029	1,493	1,746	1,171	810	457	465	395	526	737	892	891
1946-2001, cfsm	1.40	1.49	2.17	2.53	1.70	1.18	0.66	0.67	0.57	0.76	1.07	1.29	1.29
2001, cfs	475	630	1535	2669	651	1012	452	347	263	235	268	298	736
2001, cfsm	0.69	0.91	2.23	3.87	0.94	1.47	0.66	0.50	0.38	0.34	0.39	0.43	1.07
Ware River at Gibbs Cross													
1946-2001,cfs	335	342	511	594	382	252	134	126	110	169	255	306	293
1946-2001, cfsm	1.70	1.74	2.59	3.01	1.94	1.28	0.68	0.64	0.56	0.86	1.30	1.55	1.49
1912-1935,cfs	312	284	657	722	393	233	173	129	137	137	218	278	306
1912-1935, cfsm	1.58	1.44	3.33	3.67	2.00	1.18	0.88	0.66	0.70	0.70	1.10	1.41	1.55
2001, cfs	182	241	629	1160	208	440	155	87	60	32	38	92	277
2001 cfsm	0.92	1.22	3.19	5.89	1.06	2.23	0.79	0.44	0.30	0.16	0.19	0.47	1.41
Swift River at West Ware													
1946-2001,cfs	77	82	89	185	177	136	81	84	85	77	83	77	103
1946-2001, cfsm	0.41	0.44	0.47	0.98	0.94	0.72	0.43	0.44	0.45	0.41	0.44	0.41	0.54
1912-1935,cfs	295	262	556	698	414	257	181	144	147	139	215	276	299
1912-1935, cfsm	1.56	1.39	2.94	3.69	2.19	1.36	0.96	0.76	0.78	0.74	1.14	1.46	1.58
2001, cfs	31	31	34	57	88	94	69	113	105	116	119	49	75
2001 cfsm	0.16	0.16	0.18	0.30	0.47	0.50	0.36	0.60	0.56	0.61	0.63	0.26	0.40
Quaboag River at West Brimfield													
1946-2001,cfs	291	316	483	553	315	199	93	106	84	137	206	269	254
1946-2001, cfsm	1.94	2.10	3.22	3.68	2.10	1.33	0.62	0.71	0.56	0.92	1.37	1.79	1.70
1912-1935,cfs	240	218	487	524	319	175	121	111	100	96	138	202	227
1912-1935, cfsm	1.60	1.45	3.25	3.49	2.13	1.16	0.80	0.74	0.66	0.64	0.92	1.35	1.52
2001, cfs	144	185	494	989	150	196	87	44	26	38	61	69	207
2001 cfsm	0.96	1.23	3.29	6.59	1.00	1.31	0.58	0.29	0.17	0.25	0.41	0.46	1.38

Monthly average flows in the Ware and Quaboag Rivers in 2001 follow very similar patterns. From January to July, flows were nearly equal or moderately less than the flow for the 1946-2001 and 1912-35

periods for all months except April (Figures 4.2-3 and 4.2-4). In April, the average flow in the Quaboag and Ware Rivers was nearly double the average flow for the period of record in response to snowmelt and rain events. With on onset of lower precipitation patterns in the latter half of 2001 (August-December), flows in the Quaboag and Ware Rivers were well below historic averages.

However in the Swift River, the average monthly flow in April was only about one twelfth the average flow for the 1912-35 period and nearly a third less compared to the 1946-2001 period. In contrast to the Quaboag and Ware Rivers, the average monthly flows from January through July in 2001 in the Swift River were considerably less than the average for the 1946-2001 and 1912-35 periods (Figure 4.2-5). In addition, from August to November Swift River monthly average flows in 2001 were nearly equal to the 1946-2001 period, most likely due to flow augmentation from Quabbin Reservoir. Comparisons of monthly flow averages for the 1946-2001 and 1912-35 periods (Figure 4.2-5) on the Swift River reveal the drastic reduction in late and spring flows that result from water storage operations at Quabbin Reservoir.

USGS Gage Locations in the Chicopee River Basin

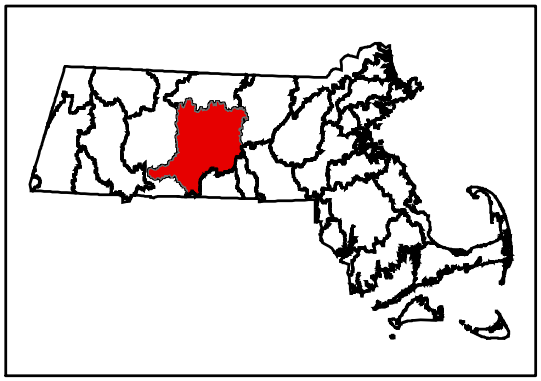


Figure 4.1-1

Figure 4.2-1: Average Annual Flow for the Period of Record and 2001

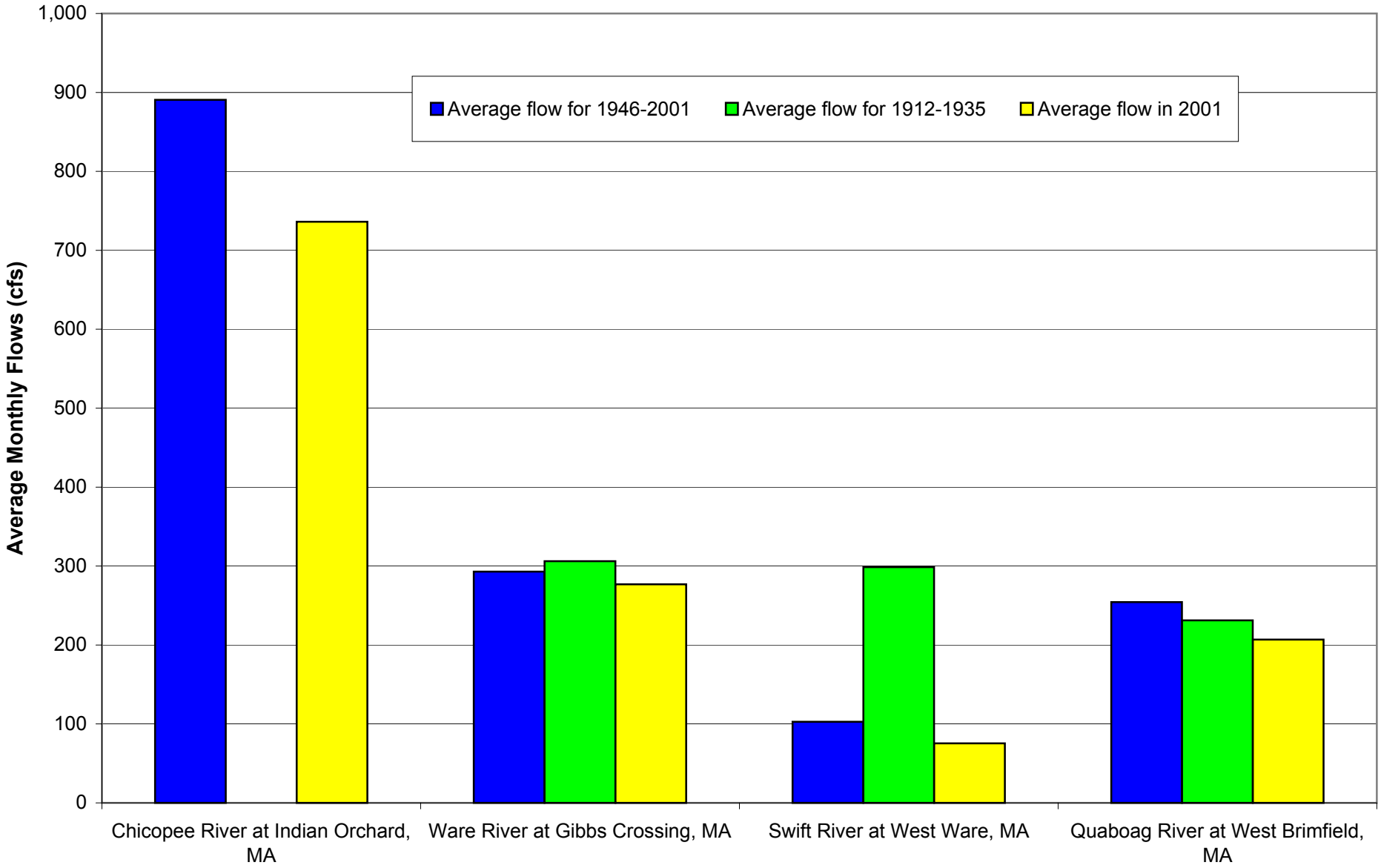


Figure 4.2-2: Monthly Average Flow-Chicopee River at Indian Orchard, MA

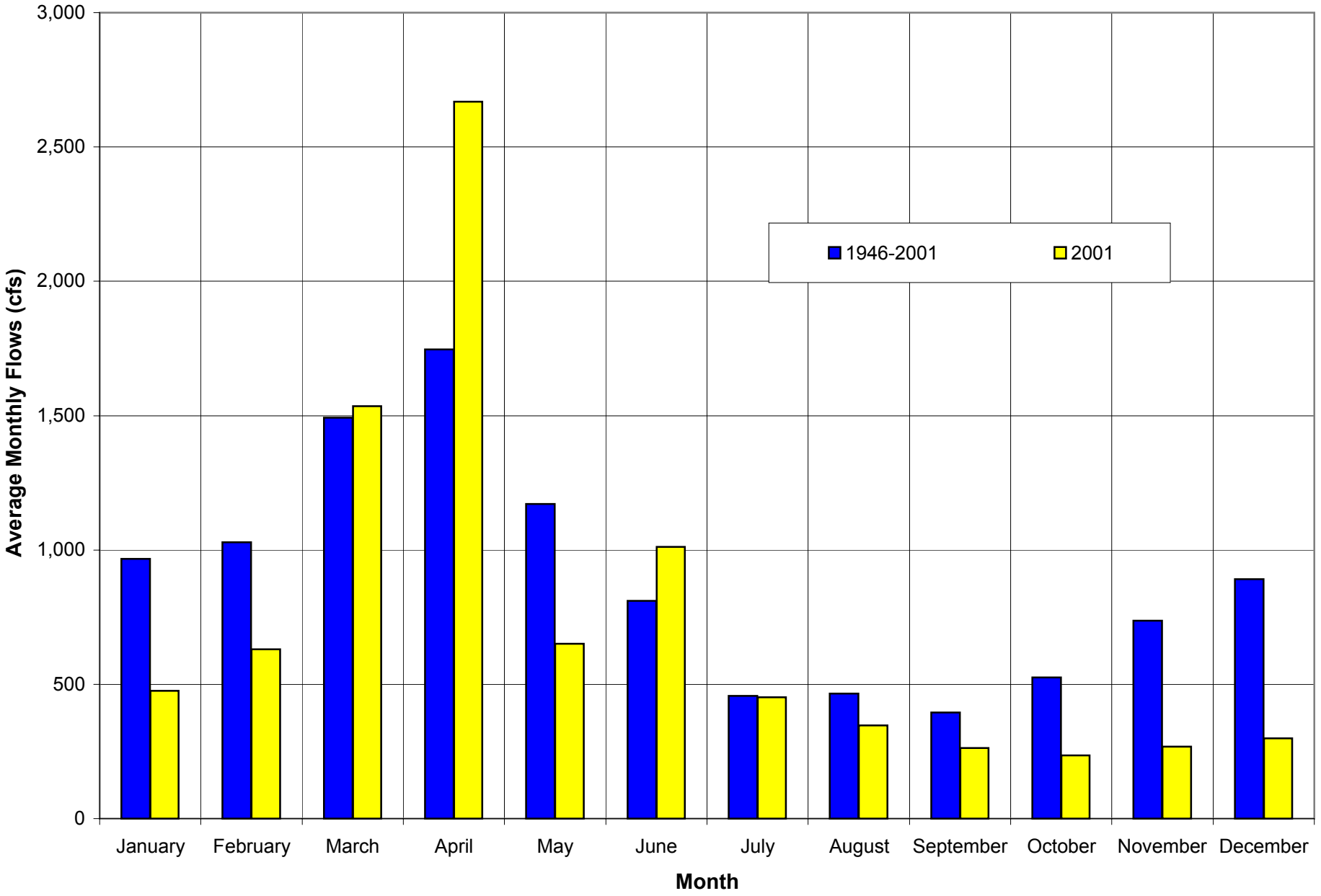


Figure 4.2-3: Monthly Average Flow-Ware River at Gibbs Crossing, MA

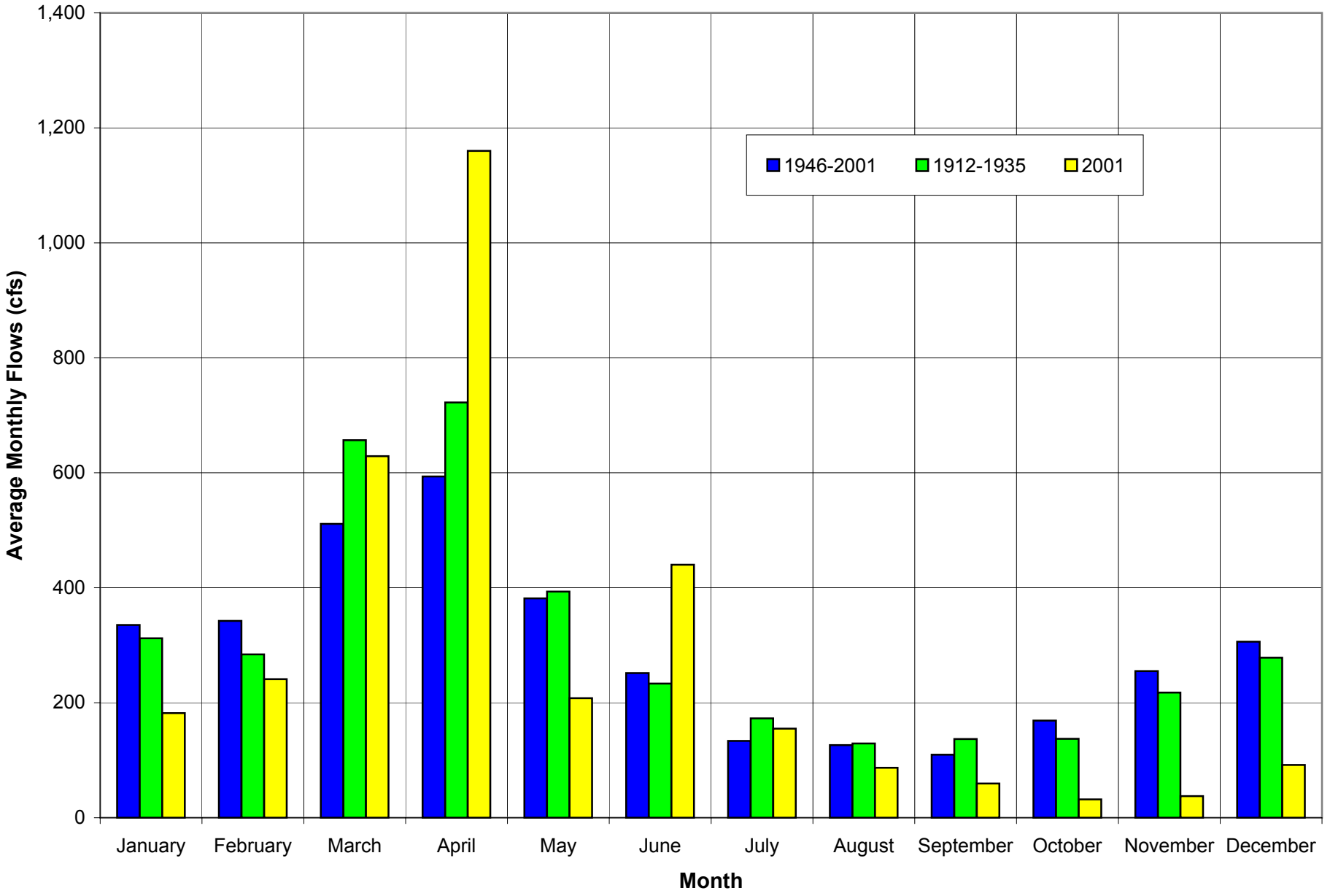


Figure 4.2-4: Monthly Average Flow-Quaboag River at West Brimfield, MA

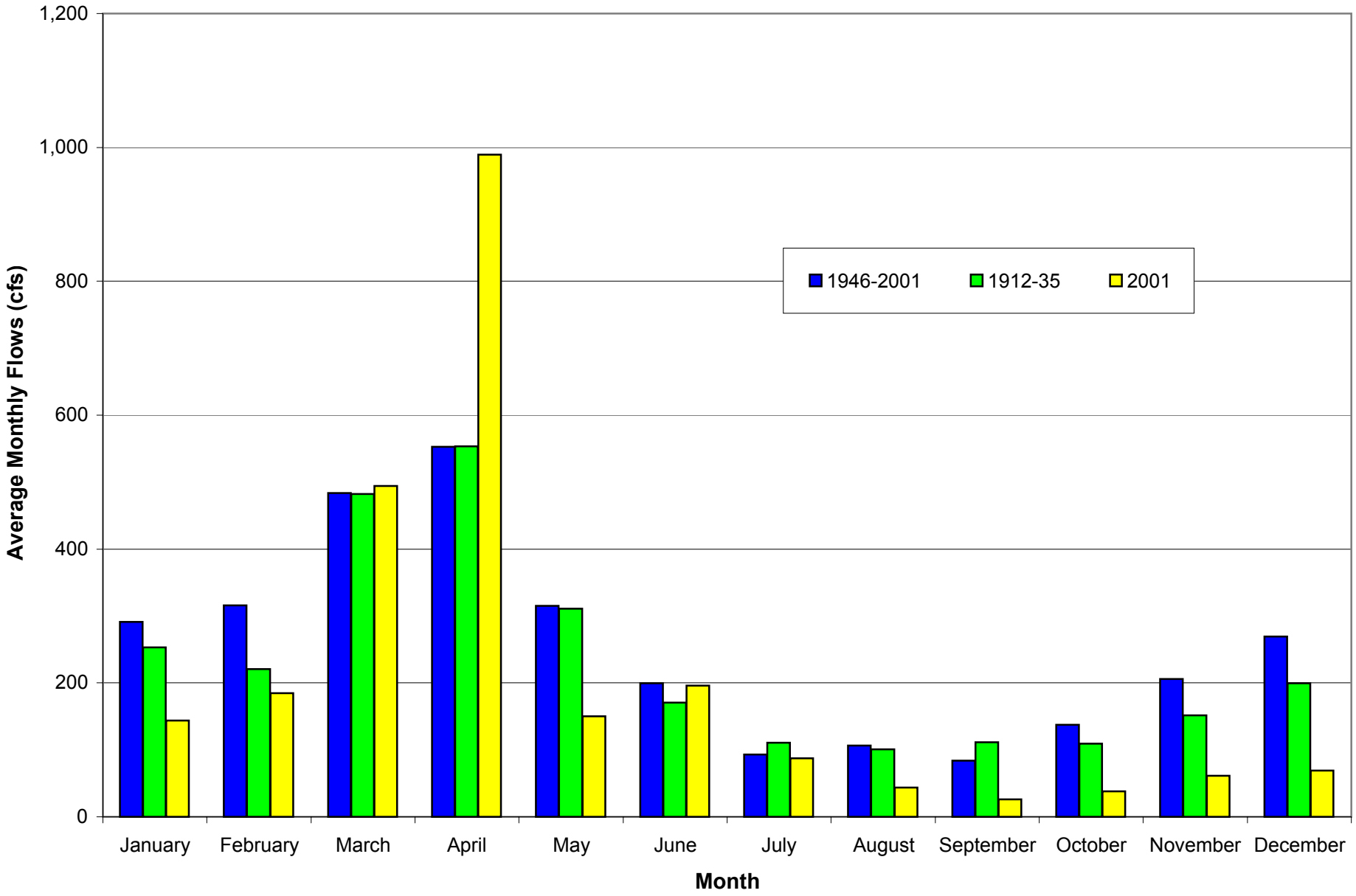
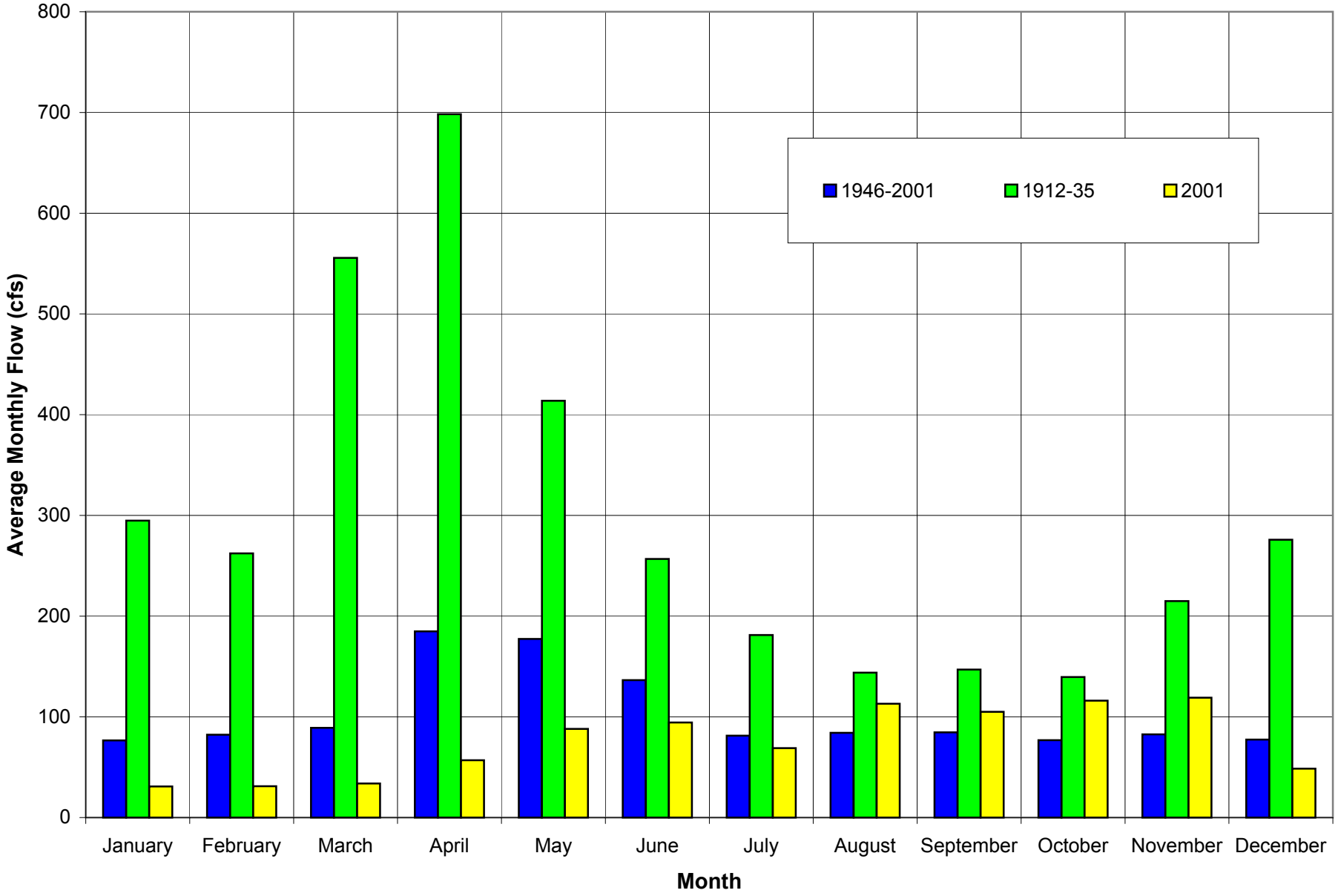


Figure 4.2-5: Monthly Average Flow-Swift River at West Ware, MA



5 Analysis of Water Withdrawal Data by Major Watershed for 2001

Water withdrawn from the watersheds in the Chicopee can take several paths. It can be used in the watershed and discharged back into the same watershed, it can be transferred to a different watershed within the Chicopee River basin, or it can be transferred out of the Chicopee River basin entirely. The last two represent a net loss of water for the watershed. This could potentially result in a shortage of water for communities and industrial users within the watershed, and low flows in the streams and waterways that aquatic life depend upon.

For this study water withdrawals include both public water supplies and industrial users that withdraw greater than 100,000 GPD on average (see Figure 5.0-1). 2001 Public Water Supply Annual Statistical Reports were obtained from the Massachusetts Department of Environmental Protection (MDEP) for each of the water users identified in the Chicopee River basin. To document water withdrawals and identify water transfers both within the basin and out of the basin, water withdrawals were entered into a database according to watershed (Swift, Ware, and Quaboag). Each watershed was then divided into subwatersheds for finer scale analysis. The following discussion addresses each major watershed and its subwatersheds.

In 2001, there were no water withdrawals in the watershed of the Chicopee River itself[2]. However, in 2001 the City of Springfield did withdraw 14,046 MG of water from their Cobble Mountain Reservoir (out-of-basin) and import a portion of it to the Chicopee River watershed. The City of Springfield lies within the Chicopee River and Connecticut River basins; an apportionment of this water between the basins could not be determined.

5.1 Swift River Watershed

5.1.1 Total and Monthly Water Withdrawals

Of the three watersheds, the Swift River watershed is the second largest (215 sq mi.), accounting for 29.8 percent of the total area of the Chicopee River basin. The watershed is divided into four subwatersheds with the largest, the Quabbin subwatershed accounting for 87.2 percent of the total watershed area. Table 5.1.1-1 lists the four subwatersheds in the Swift River watershed, and their drainage area.

Table 5.1.1-1: Subwatersheds in the Swift River Watershed

Subwatershed	Area (sq mi.)	% of Total Watershed Area
Jabish Brook	18.6	8.6%
Quabbin Watershed	187.5	87.2%
Swift below Quabbin	8.0	3.7%
Swift River Mainstem	1.0	0.5%

In 2001, there were four registered water users withdrawing in excess of 100,000 GPD from the Swift River watershed. These included three public water suppliers, and a trout hatchery operated by the Massachusetts Division of Fisheries and Wildlife (MDFW) (Table 5.1-1.2). Combined these water users withdrew approximately 80,771 MG in 2001. This accounted for 91.5 percent of the total water

[2] The Chicopee Basin includes the Swift, Ware, Quaboag, and Chicopee watersheds. A distinction is made between the Chicopee Basin and the Chicopee River watershed.

withdrawn from the Chicopee River basin, with the Ware River watershed second (6,303 MG) and the Quaboag third (1,223 MG).

Table 5.1.1-2: Registered Water Users in the Swift River Watershed

Registered Water User	Total Water Withdrawn (MG) in 2001	% of Total withdrawal	Withdrawal Subwatershed
Belchertown Water District	40	0.1%	Jabish Brook
Bondsville Water District	94	0.1%	Jabish Brook
Massachusetts Water Resources Authority	79,119	97.9%	Quabbin Watershed
McLaughlin State Hatchery	1,518	1.9%	Swift Below Quabbin

Of the four registered water users in the Swift River watershed, the Massachusetts Water Resources Authority (MWRA) withdrawals accounted for approximately 98 percent of the total water withdrawn from the Swift River watershed. McLaughlin State Fish Hatchery was second accounting for only 1.9 percent of the total water withdrawal, while the Belchertown and Bondsville water districts accounted for less than 1 percent. Water withdrawals made by the MWRA account for a significant portion of the water withdrawn not only from the Swift River watershed but the entire Chicopee River basin. The MWRA uses two water withdrawal sources, the Chicopee Valley Aqueduct, and the Quabbin Aqueduct, both located in the Quabbin subwatershed.

Monthly withdrawal patterns in the Swift River watershed are generally controlled by the MWRA. Peak water withdrawals in 2001 occurred from August through November with the greatest water demand occurring in October (Figure 5.1.1-1). April appeared to have the lowest average water withdrawal in 2001; however this was partly the result of water being transferred from the Ware River to the Swift River basin. This will be discussed in greater detail later in the report.

5.1.2 Total and Monthly Water Withdrawals Diverted to another Watershed (within Chicopee basin)

Not all the water withdrawn from the Swift River watershed is used within the watershed; some of it is diverted to other watersheds within the Chicopee. In 2001, Bondsville Water District sold 44.6 MG to the Thorndike Water District located within the Ware River watershed. This represents an interbasin transfer of water from the Jabish Brook subwatershed in the Swift River watershed to the Ware mainstem subwatershed in the Ware River watershed. Although this represents a diversion of water out of the Swift River watershed, it is relatively minor representing only 0.06 percent of the water withdrawn from the Swift River watershed. The monthly transfer of water to the Ware River watershed was similar throughout the year with quantities ranging from 2.9 MG in February to 4.6 MG in July (Figure 5.1.2-1). In 2001, water was also transferred from the Ware River mainstem to the Quabbin subwatershed. As part of the MWRA operations, 4,112 MG was transferred from the Ware River to the Quabbin Reservoir during the month of April to supplement withdrawals from the Chicopee Valley and Quabbin Aqueducts. This accounts for the apparently lower water withdrawal during the month of April discussed previously. If the water transferred from the Ware River watershed to the Swift River watershed is accounted for, then the water withdrawal for the Swift River watershed during April is similar to that of February and May.

5.1.3 Total and Monthly Water Withdrawals Diverted from the Swift River Watershed Outside the Chicopee River Basin

All the water withdrawn by the MWRA is transferred out of the Chicopee River basin. In 2001, this totaled 79,119 MG or 98 percent of the water withdrawn from the Swift River watershed. Water was

transferred through the Quabbin Aqueduct and the MWRA system to the Nashua, Blackstone, SUASCO, and Boston Harbor basins to provide much of metropolitan Boston with drinking water. The remaining water withdrawn from the Swift River watershed was transferred through the Chicopee Valley Aqueduct to the Connecticut River basin to provide water for the towns of South Hadley, Wilbraham, and Chicopee (Figure 5.1.3-1). Peak water transfers for both aqueducts occurred during the late summer and fall months (Figure 5.1.3-2).

Although relatively minor, water was also imported from Connecticut River basin to the Jabish Brook subwatershed. In 2001, Belchertown Water District pumped just under 64.5 MG from its Daigle Well located just outside the Chicopee in the Connecticut River basin (Figure 5.1.3-3).

5.2 Ware River Watershed

5.2.1 Total and Monthly Water Withdrawals

The Ware River watershed is the largest of the three watersheds (217 sq mi.), accounting for 30 percent of the total Chicopee basin area. It is divided into 17 subwatersheds with the Ware Mainstem (47.8 sq mi.) the largest. Table 5.2.1-1 lists the seventeen subwatersheds in the Ware River watershed, and their drainage area.

Table 5.2.1-1: Subwatersheds in the Ware River Watershed

Subwatershed	Area (sq mi.)	% of Total Watershed Area
Burnshirt River	17.3	8.0%
Danforth Brook	5.4	2.5%
E Branch Ware	22.3	10.3%
Flat Brook	6.8	3.1%
Longmeadow Brook	11.4	5.3%
Moose Brook	10.1	4.7%
Muddy Brook	20.0	9.2%
Natty Canesto Brook	13.2	6.1%
Parkers Brook	5.5	2.5%
Penny Brook	7.0	3.2%
Pine Hill Brook	2.7	1.2%
Pratt Brook	7.5	3.5%
Prince River	14.0	6.4%
Thompson Lake	3.6	1.7%
W Branch Ware	16.6	7.7%
Ware Mainstem	47.8	22.0%
Winimusset Brook	5.6	2.6%

In 2001 there were seven registered water users withdrawing in excess of 100,000 GPD identified within the Ware River watershed. This includes five public water suppliers, one industrial user, and a salmon hatchery operated by MDFW. Combined they withdrew approximately 6,303 MG of water from the Ware River watershed in 2001. This accounted for just 7.1 percent of the water withdrawn from the Chicopee River basin. Table 5.2.1-2 lists the registered water users in the Ware River watershed and the subwatersheds from which the water was withdrawn.

Table 5.2.1-2: Registered Water Users in the Ware River Watershed

Registered Water User	Total Water Withdrawn (MG) in 2001	% of Total Withdrawn	Withdrawal Subwatershed
Fitchburg Water Department	1,341	21.3%	E Branch Ware
Salmon Hatchery	220	3.5%	Thompson Lake
Barre Water Department	78	1.2%	Pratt Brook
Barre Water Department	76	1.2%	Prince River
Ware Water Department	214	3.4%	Muddy Brook
Ware Water Department	74	1.2%	Ware Mainstem
Three Rivers Fire District	119	1.9%	Ware Mainstem
Cascades-Diamond, Inc.	69	1.1%	Ware Mainstem
Massachusetts Water Resources Authority	4,112	65.2%	Ware Mainstem

Water withdrawn by the MWRA from the Ware Mainstem totaled 4,112 MG and accounted for 65 percent of the water withdrawn from the Ware River watershed. This large withdrawal only occurred during the month of April, when water was transferred to the Quabbin Reservoir to supplement future water demands. According to MWRA, the current operating practice limits use of the Ware River to periods when Quabbin Reservoir levels are below their seasonal normal values. Water withdrawals by Fitchburg Water Department were second totaling 1,341 MG or 21.3 percent of the total. The remaining five water users combined withdrew 850 MG and accounted for the remaining 13.5 percent. Out of the 17 subwatersheds the Ware Mainstem had the highest demand, supplying over 69 percent of the water withdrawn from the Ware River watershed, while the East Branch of the Ware River was second supplying 21.3 percent.

The highest average monthly water withdrawal in 2001 occurred in April when a total of 4,112 MG was withdrawn. This was a result of the MWRA transferring water to the Quabbin Reservoir. If this transfer is excluded, the peak water demand occurred during the late summer and fall months with the highest demand occurring in August and September, and the lowest demand in January (Figure 5.2.1-1).

5.2.2 Total and Monthly Water Withdrawals Diverted to another Watershed within the Chicopee basin

Within the Ware River watershed there are two sources of interbasin transfers: 1) MWRA transfers water from the Ware River to the Quabbin Reservoir (Swift River watershed) and 2) the Thorndike Water District in the Ware Mainstem subwatershed imports all their water from the Bondsville Water District in the Swift River watershed. In 2001, the Ware River watershed experienced a loss of nearly 4,067 MG due to interbasin transfers. Although Thorndike imported 44.6 MG of water into the Ware River basin in 2001, it was relatively minor compared to the 4,112 MG that was exported.

Each year water is transferred from the Ware River to Quabbin Reservoir as needed between October 15th and June 15th when flow in the Ware River exceeds 85 MGD. The transfer is used to increase the safe yield of the Quabbin Reservoir. In 2001, 4,112 MG were transferred during April accounting for nearly 99 percent of the total interbasin transfer occurring in the Ware River basin. The remaining one percent of water was imported throughout 2001 with the peak demand occurring during the summer months of June, July, and August (Figure 5.2.2-1).

5.2.3 Total and Monthly Water Withdrawals Diverted Outside the Chicopee River Basin

A total of 1,341 MG of water is transferred outside the Chicopee River basin. The Fitchburg Water Department transfers water from the Ware River watershed to the Nashua River basin. Water removed from Bickford Pond and Mare Meadow Reservoir in the East Branch of the Ware River watershed is used to help supply the towns of Fitchburg and Westminster. Bickford Pond serving primarily as a supplemental water source transfers water to the Mare Meadow Reservoir. In 2001, just over 551 MG was transferred to Mare Meadow Reservoir to help offset water demands. Water from Mare Meadow Reservoir is then transferred out of the Chicopee River basin to Meeting House Reservoir before being sent to the towns of Fitchburg and Westminster. In 2001, 1,341 MG transferred from the Mare Meadow Reservoir accounted for approximately 21 percent of the total water withdrawal from the Ware River basin.

The transfer of water from Bickford Pond to Mare Meadow Reservoir occurred from September through December of 2001. Peak demand on Bickford Pond occurred in September with just over 206 MG being transferred, while the lightest demand occurred in November with a transfer of just over 9 MG. Water transfers from Mare Meadow Reservoir to the Meetinghouse Reservoir in the Nashua River basin occurred during all months except January and April in 2001. Peak demand generally occurred from August through December with just over 71 percent of the water being transferred during these months (Figure 5.2.3-1).

5.3 Quaboag River Watershed

5.3.1 Total and Monthly Water Withdrawals

The Quaboag River watershed is the smallest of the three major watersheds (212 sq mi.) accounting for just over 29 percent of the total area of the Chicopee River basin. It is divided into 18 subwatersheds with the Quaboag Mainstem the largest (57.5 sq mi). Table 5.3.1-1 lists the eighteen subwatersheds in the Quaboag River watershed, and their drainage area.

Table 5.3.1-1: **Subwatersheds in the Quaboag River Watershed**

Subwatershed	Area (sq mi.)	% of Total Watershed Area
Shaw Brook	6.0	2.9%
Turkey Hill Brook	10.2	4.8%
Seven Mile River	9.5	4.5%
Cranberry River	6.5	3.1%
Five Mile River	24.9	11.7%
Great Brook	4.2	2.0%
Dunn Brook	6.8	3.2%
Trout Brook	4.0	1.9%
Willow Brook	2.4	1.1%
Coys Brook	8.4	3.9%
Lake Wickaboag	17.7	8.4%
Naultaug Brook	3.9	1.9%
Lamberton Brook	4.5	2.1%
Kings Brook	4.0	1.9%
Blodgett Mill Br	7.7	3.6%

Subwatershed	Area (sq mi.)	% of Total Watershed Area
Foskett Mill Brook	9.8	4.6%
Chicopee Brook	24.0	11.3%
Quaboag Mainstem	57.5	27.1%

In 2001, there were eleven registered water users withdrawing greater than 100,000 GPD within the Quaboag River watershed. These included nine public water suppliers and two industrial users. Combined they withdrew just over 1,223 MG and accounted for only 1.4 percent of the total water withdrawn from the Chicopee River basin. Table 5.3.1-2 lists the registered water users in the Quaboag River watershed and the subwatersheds from which the water was withdrawn.

Table 5.3.1-2: Registered Water Users in the Quaboag River Watershed

Registered Water User	Total Water Withdrawn (MG) 2001	% of Total Withdrawn	Withdrawal Subwatershed
Bond Construction	48	3.9%	Quaboag Mainstem
Brookfield Water Department	40	3.3%	Quaboag Mainstem
East Brookfield Water Department	47	3.8%	Quaboag Mainstem
Hardwick Knitted Fabric	79	6.4%	Quaboag Mainstem
Monson Water & Sewer	191	15.6%	Chicopee Brook
North Brookfield Water Department	160	13.1%	Five Mile River
Palmer Fire Department	177	14.5%	Quaboag Mainstem
Spencer Water Department	136	11.1%	Cranberry River
Spencer Water Department	134	11.0%	Quaboag Mainstem
Warren Water District	90	7.3%	Quaboag Mainstem
West Brookfield Water Department	3.2	0.3%	Lake Wickaboag
West Brookfield Water Department	80	6.5%	Quaboag Mainstem
West Warren Water District	39	3.2%	Quaboag Mainstem

Water withdrawn by the Spencer Water Department from two wells located in the Cranberry River and Quaboag Mainstem watersheds totaling just over 270 MG accounted for 22 percent of the water withdrawn from the Quaboag River watershed. Monson Water and Sewer was second with 191 MG or 15.6 percent, and North Brookfield was third with 160 MG or 13.1 percent. Out of the 18 subwatersheds, the Quaboag Mainstem had the greatest demand on its water resources. Nine registered users withdrew 732 MG in 2001 accounting for nearly 60 percent of the water withdrawn from the Quaboag River watershed. The Chicopee Brook subwatershed was second with 191 MG or 15.6 percent, and the Five Mile River was third with 160 MG or 13.1 percent. Water demand was similar throughout the year with peak water withdrawal occurring during May and June, while the least amount of water was withdrawn during the winter months (Figure 5.3.1-1). Unlike the Swift and Ware River watersheds that experience transfers of water both within the basin and out of the basin, no such transfers of water occur in the Quaboag River watershed. All the water withdrawn by the eleven registered water users from the Quaboag River watershed remains in the watershed.

Major Water Withdrawals (>100,000gpd) within Chicopee River Basin

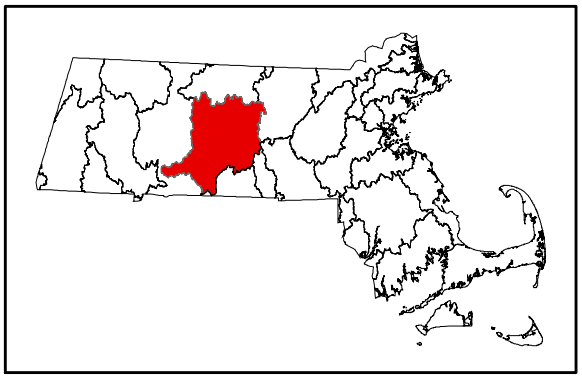


Figure 5.0-1

Figure 5.1.1-1: Monthly Water Withdrawals from the Swift River Watershed in 2001

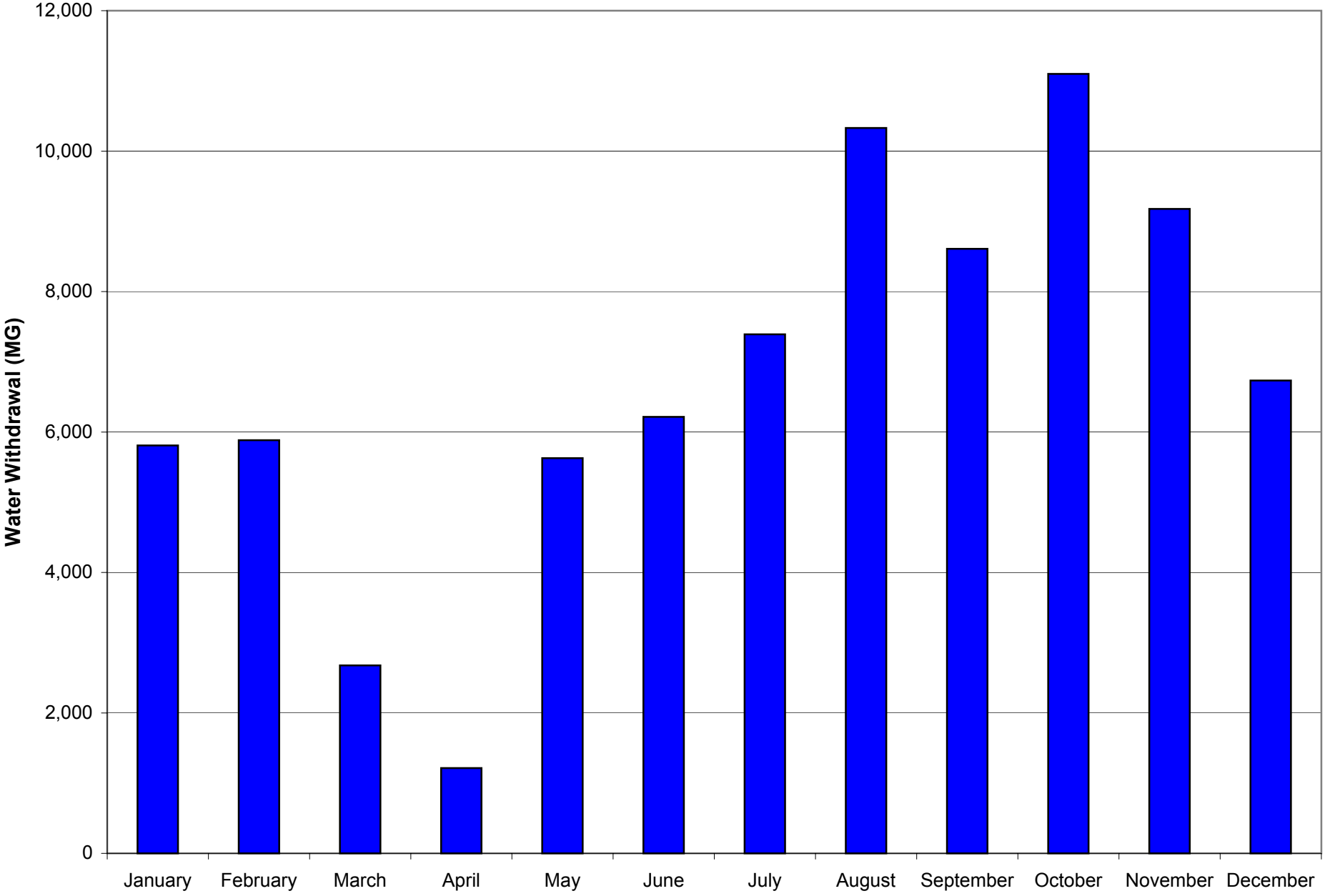


Figure 5.1.2-1: Monthly Volume of Water Transferred from the Swift River Watershed to the Ware River Watershed in 2001

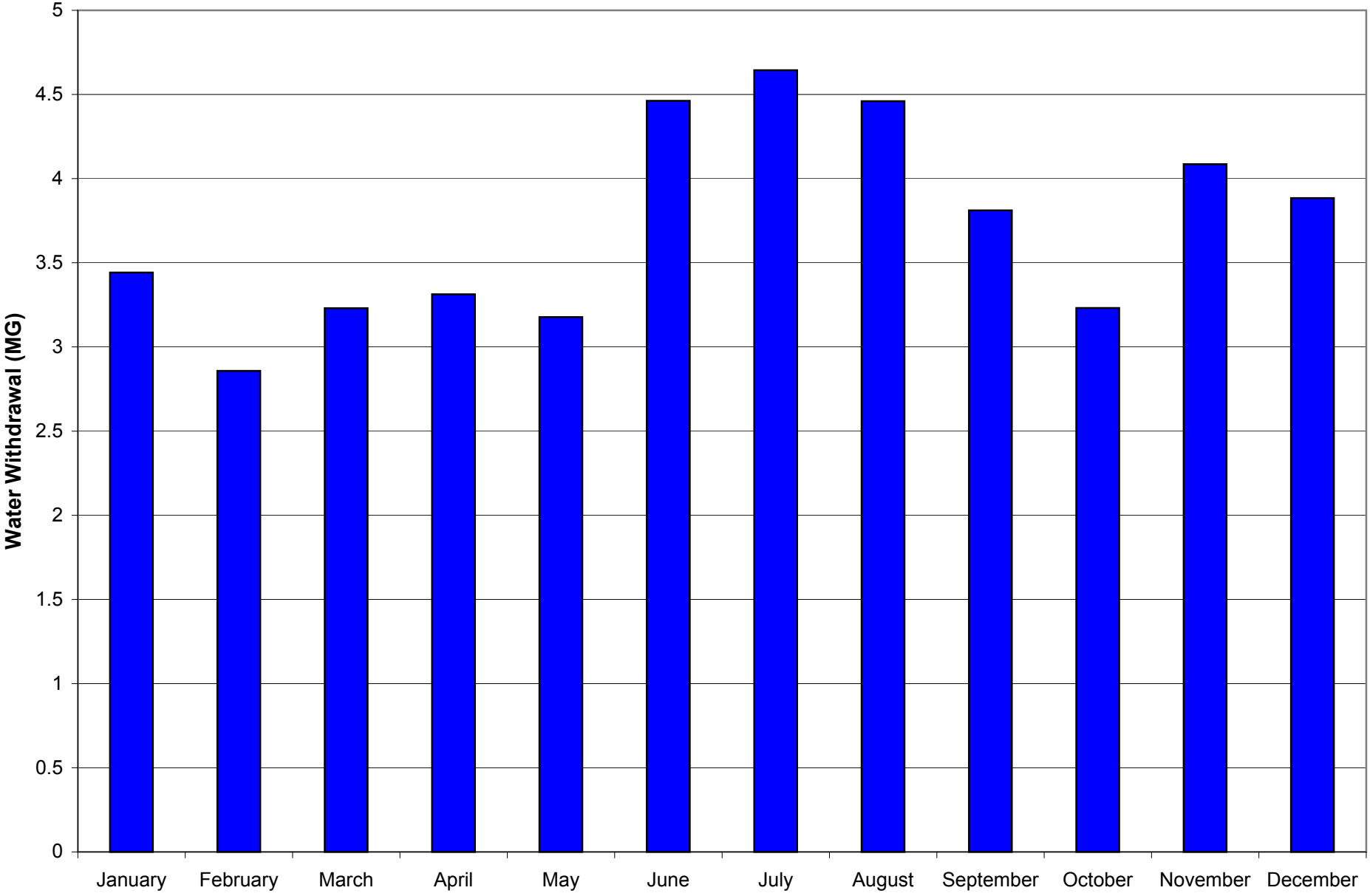


Figure 5.1.3-1: Total Water Withdrawn from the Swift River Watershed by the Massachusetts Water Resources Authority in 2001

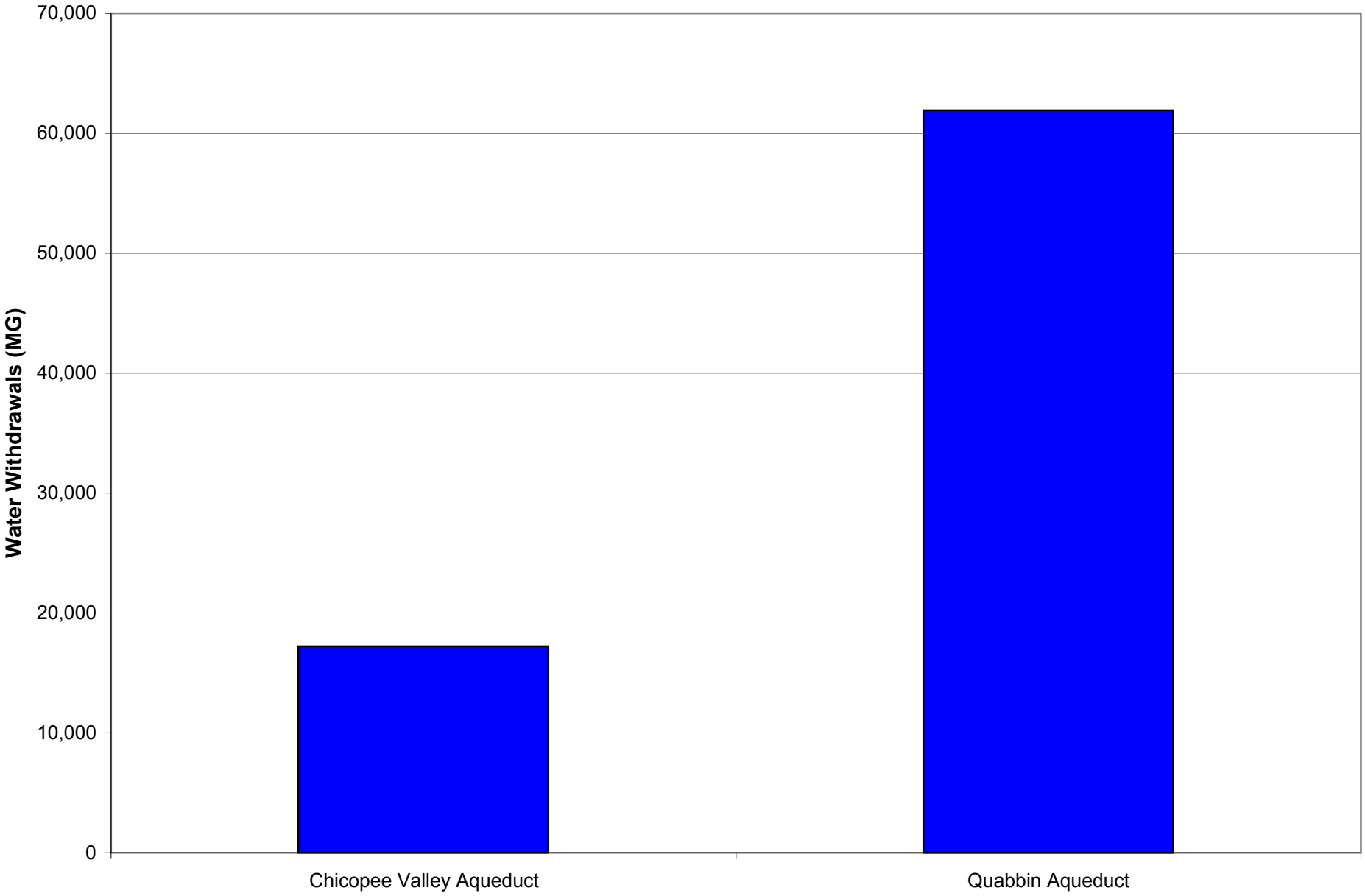


Figure 5.1.3-2: Water Transferred from the Swift River Basin Outside of the Chicopee River Basin in 2001 by Month

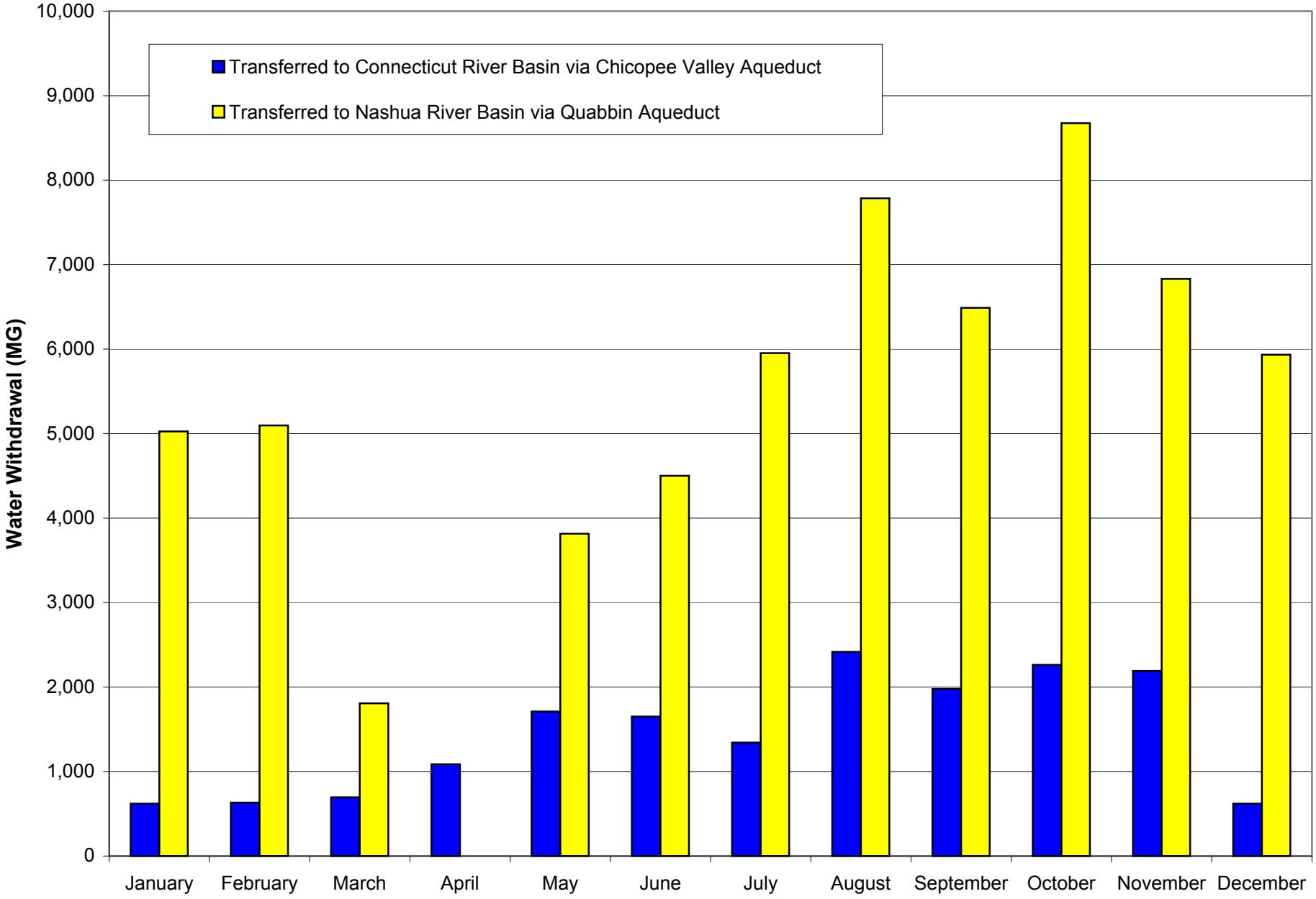


Figure 5.1.3-3: Water Transferred from the Connecticut River Basin to the Swift River Watershed in 2001

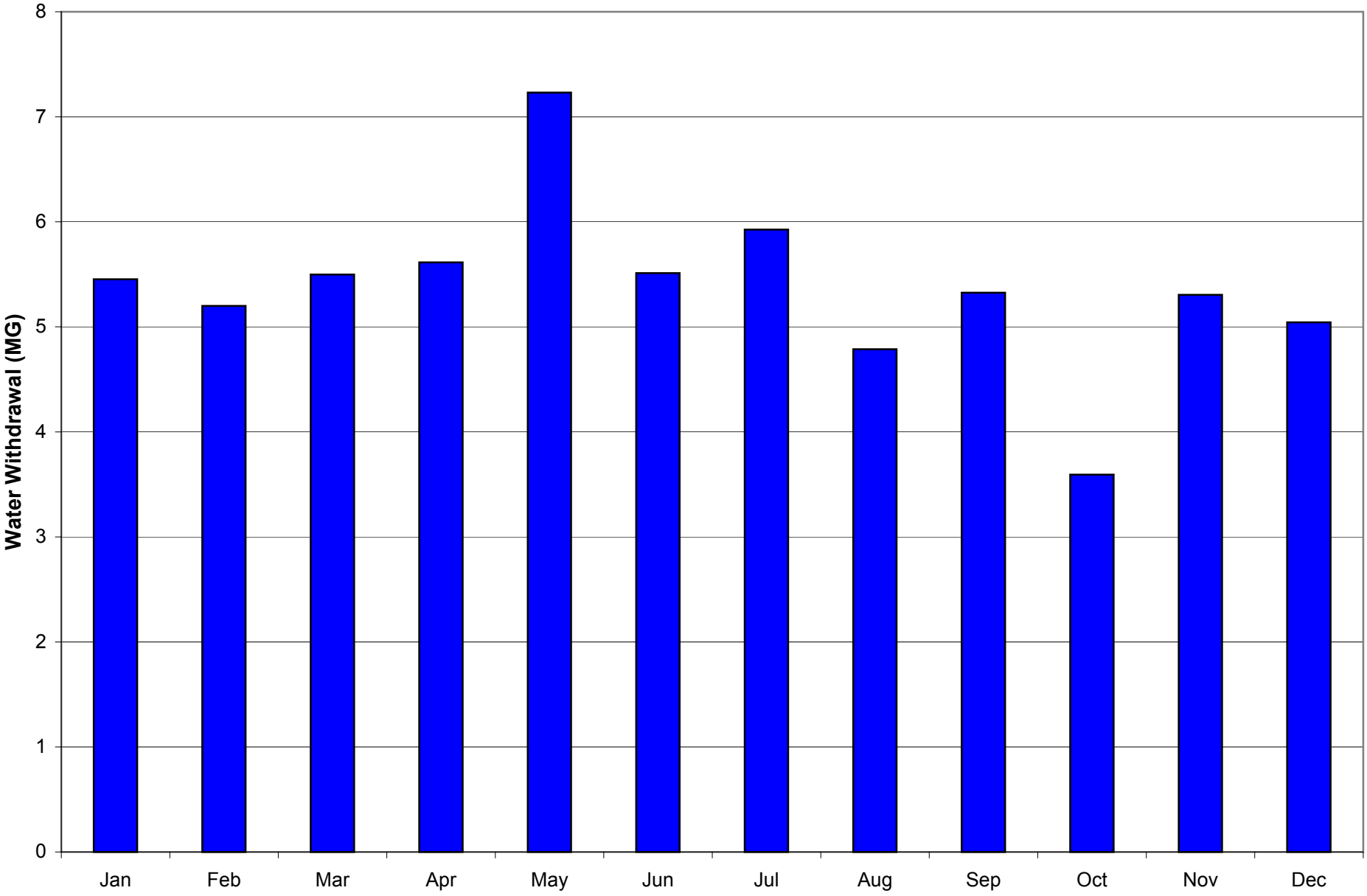


Figure 5.2.1-1: Monthly Water Withdrawals in Ware River Basin in 2001

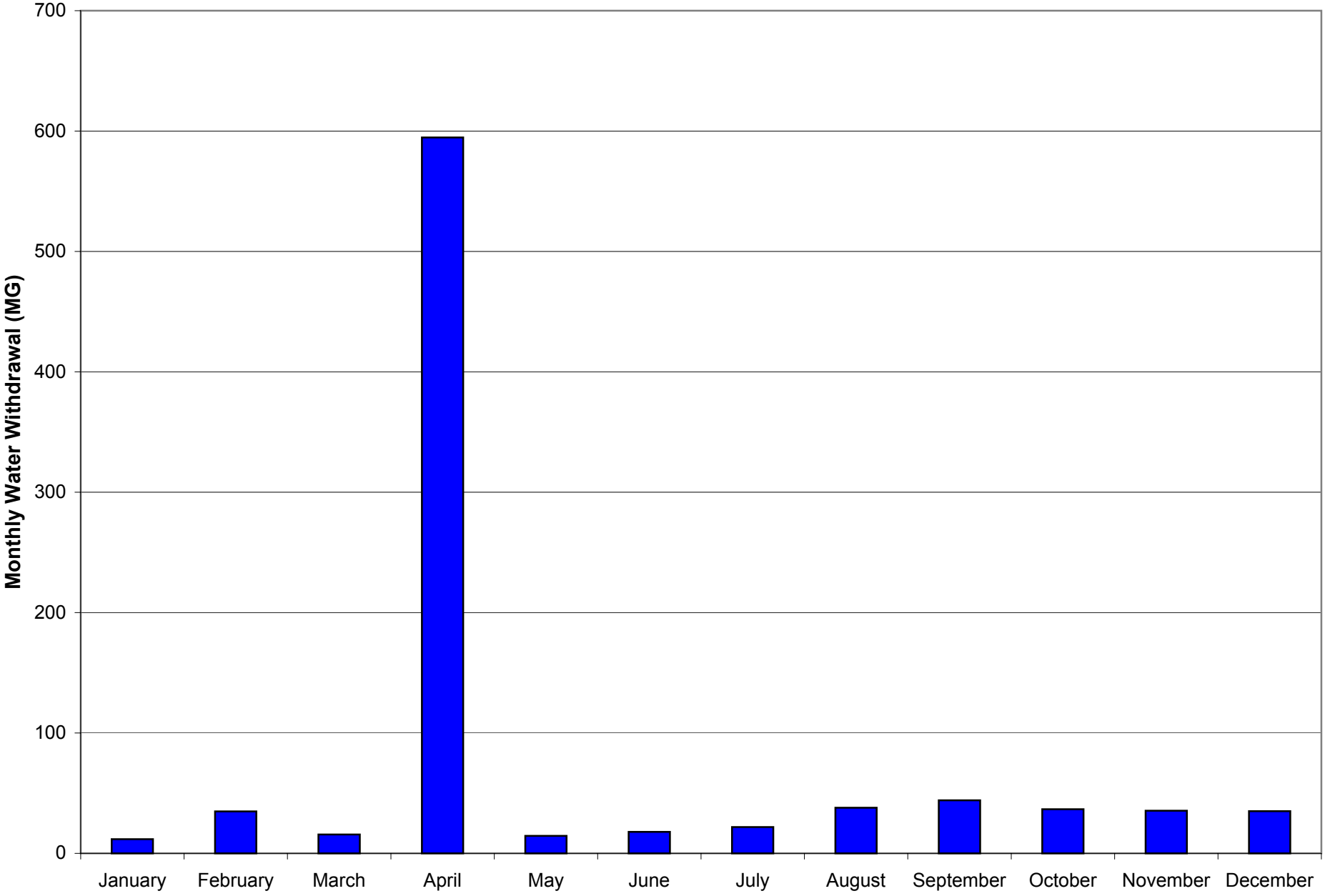


Figure 5.2.2-1: Interbasin Transfers for the Ware River Subbasin in 2001

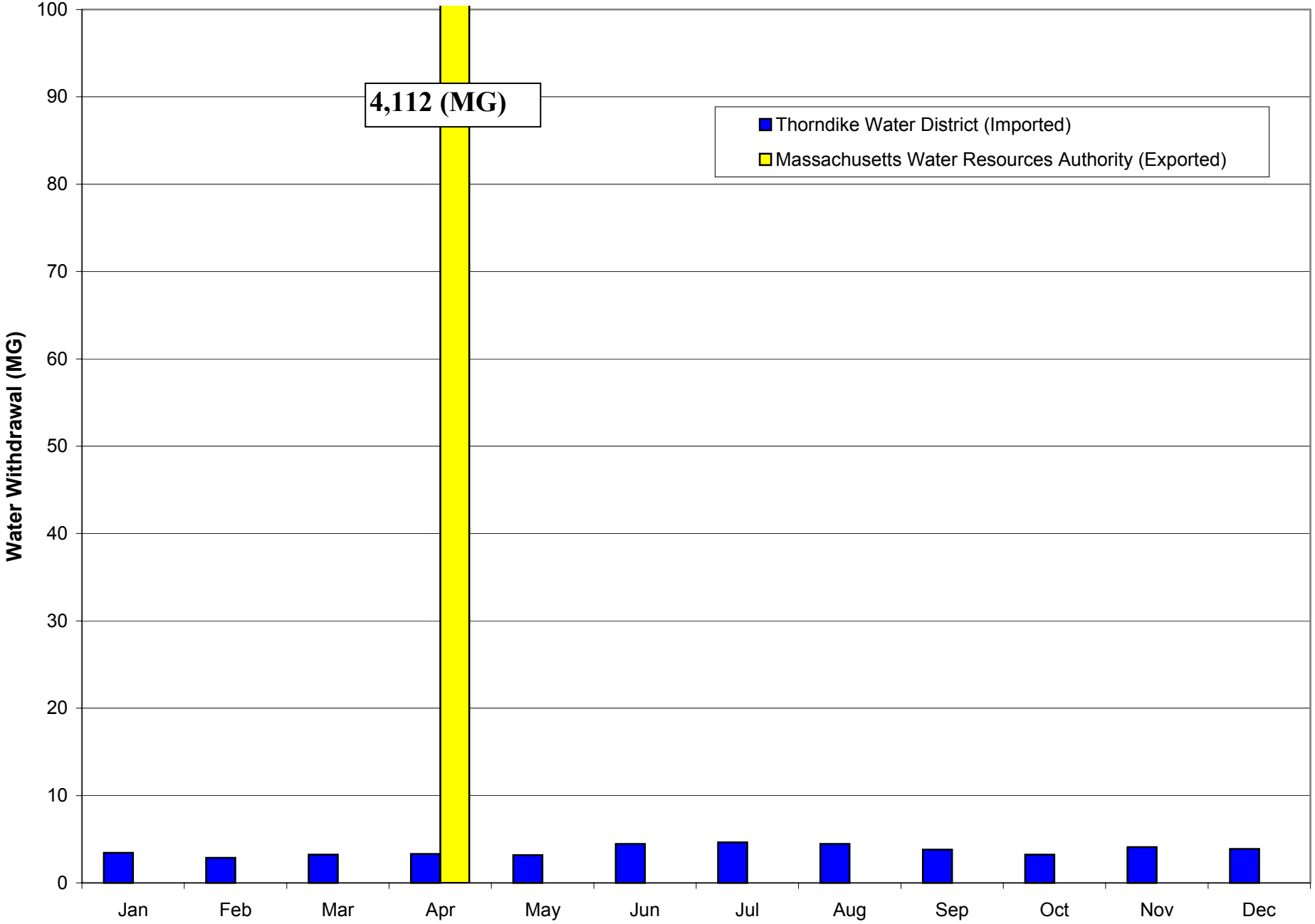


Figure 5.2.3-1: Water Transferred from the Ware River Watershed Outside of the Chicopee Basin in 2001

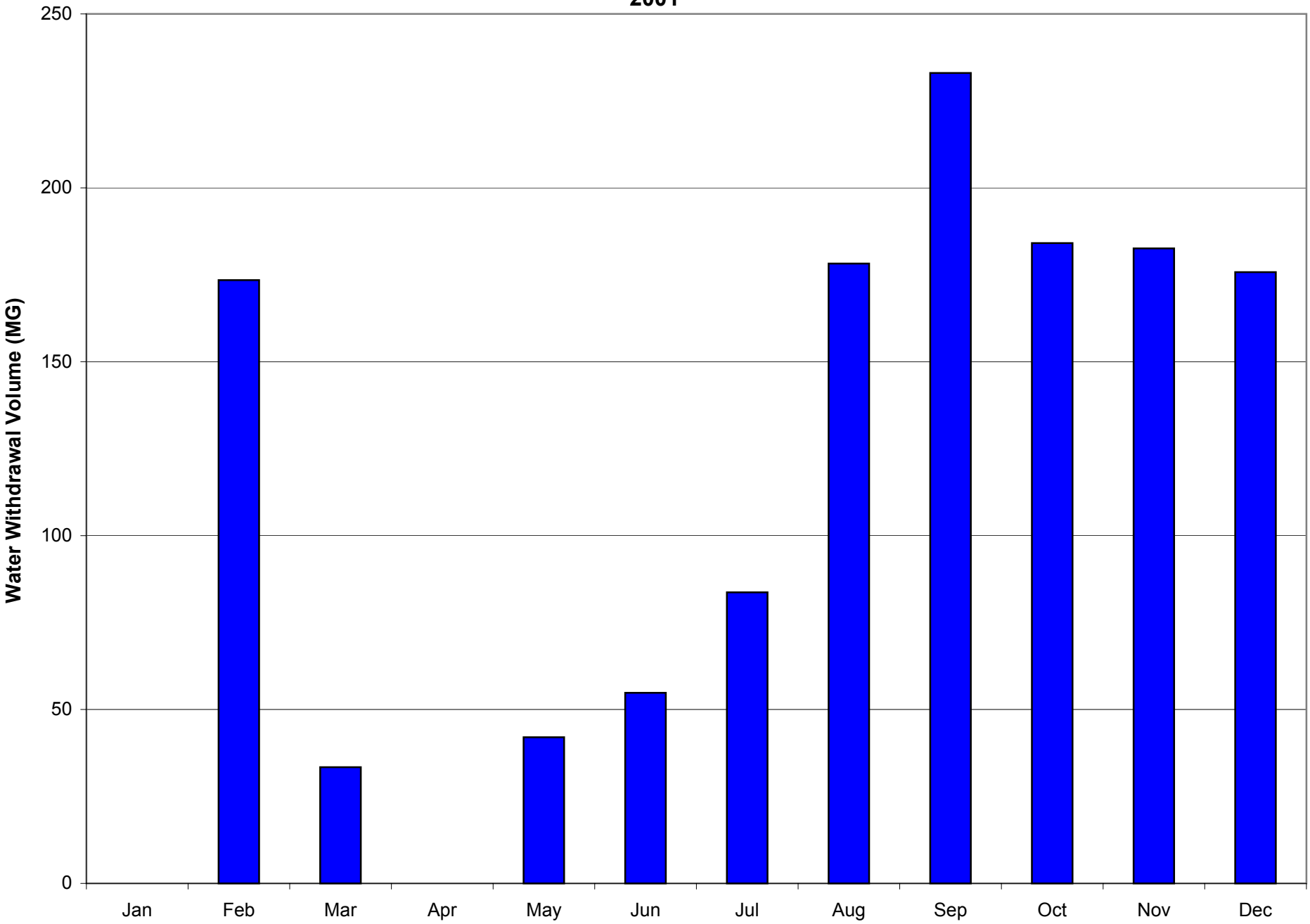
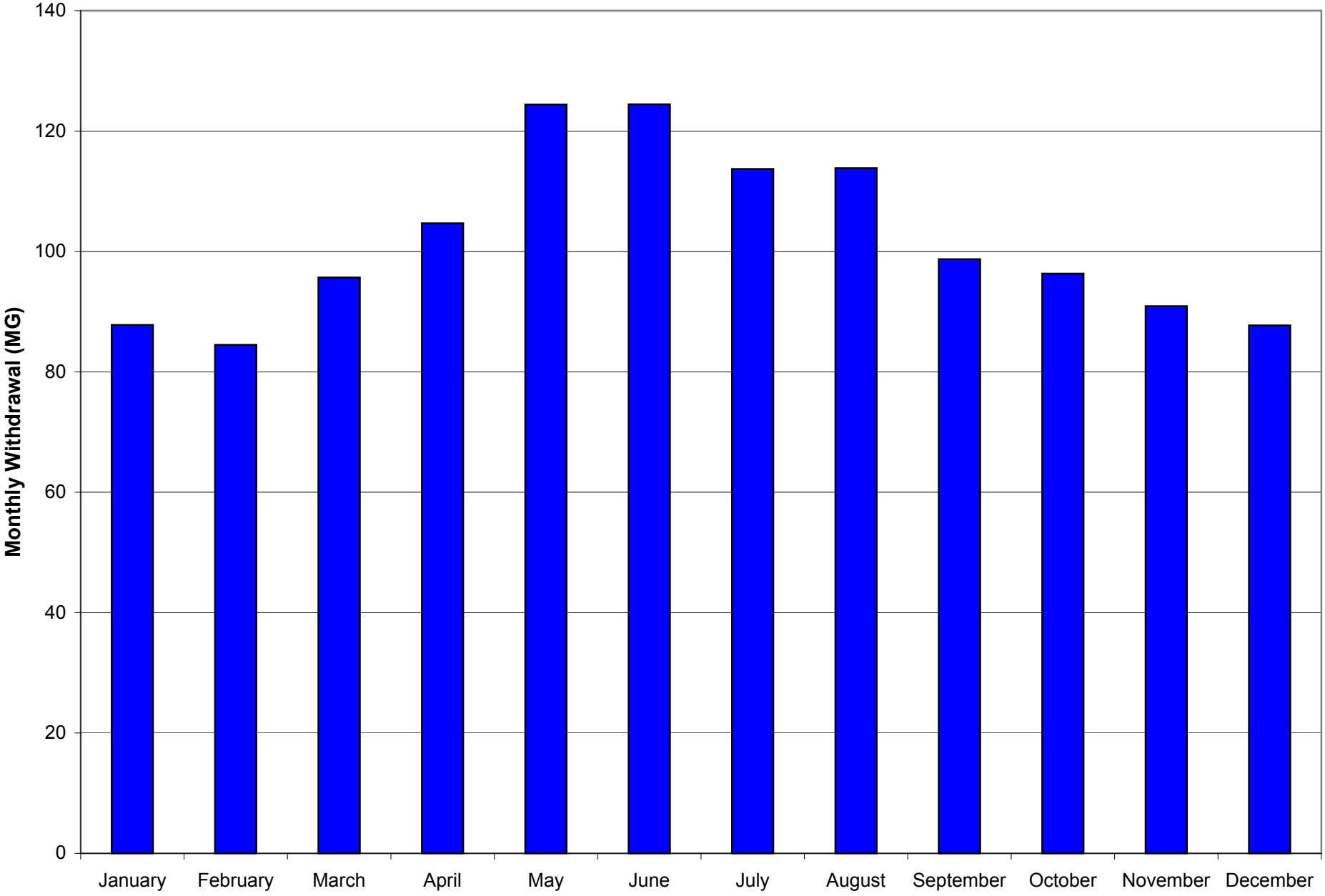


Figure 5.3.1-1: Monthly Water Withdrawals from the Quaboag River Basin in 2001



6 NPDES Dischargers in the Chicopee River Basin

Overall, the NPDES dischargers act as another means to transfer water both as interbasin transfers and transfers into and out of the Chicopee River basin. Facilities permitted to discharge treated wastewater in receiving waters within the Chicopee River basin are listed in Table 6-1. This includes nine municipal wastewater treatment plants. Four of these (Barre, Gilbertville, Wheelwright, and Ware) discharge to the Ware River; two (Spencer, and Warren) discharge to the Quaboag River or a tributary; the Palmer wastewater treatment plant discharges to the Chicopee River, close to the confluence of the Ware and Quaboag rivers; the Chicopee and Springfield wastewater treatment plants discharge to points near the confluence of the Chicopee and Connecticut rivers. Thus, a portion of this wastewater is discharged directly to the Connecticut River basin. Together, annual municipal wastewater discharges for 2001 were 63 MGD.

Springfield, Chicopee and Palmer are also permitted to discharge into the Chicopee River through a number of combined sewer overflows (CSOs). In addition, wastewater from several additional communities is collected and transferred out of the basin. This occurs in all or parts of Belchertown, Templeton, Rutland, Ludlow, Wilbraham, and Springfield. There are six industrial dischargers to the Chicopee River basin. Their total average annual discharge is approximately 7.06 MGD.

Table 6-1: NPDES Dischargers in the Chicopee River Basin

Name	Permit Number	Type of Discharge	Receiving Waters	Average Annual Discharge (MGD)
Storm Forge Division	MAG250947	Plant Wastewater	Poor Brook to Chicopee	0.05
Eastern Etching	MA0000647	Process Wastewater	Chicopee River	0.04*
Soultia, Inc.	MA 0001147	Plant Wastewater	Chicopee River	2.07
Springfield WWTF	MA0101613	Municipal Wastewater	Conneticut and Chicopee	42.8
Chicopee WPC	MA0101508	Municipal Wastewater	Conneticut and Chicopee	9.09
**Thermotech	MAG250376	Plant Wastewater	Chicopee Brook	0.06
Warren WWTP	MA0101567	Municipal Wastewater	Quaboag River	0.59
Spencer WWTP	MA0100919	Municipal Wastewater	Seven Mile River	0.37
Wheelwright WWTP	MA0102431	Municipal Wastewater	Ware River	0.03*
Gilbertville WWTP	MA0100102	Municipal Wastewater	Ware River	0.14*
Quabbin Wire	MA0030571	Plant Wastewater	Ware River	0.06
Barre WWTP	MA0103152	Municipal Wastewater	Ware River	6.89
Ware WWTP	MA0100889	Municipal Wastewater	Ware River	0.73
Palmer WPCF	MA0101168	Municipal Wastewater	Ware/Quaboag/Swift	2.23
McLaughlin Trout Hatchery	MA0110043	Fish Waste Discharge	Swift River	4.78

* Permitted flow.

** Only maximum monthly data available.

7 Comparison between Water Withdrawal Volumes and Flow Volumes by Major Watershed

Table 7-1 compares monthly water withdrawals, inter-basin transfer volumes and recorded streamflow within the Swift River watershed for 2001. The amount of water transferred from the Swift River watershed during 2001 was substantially greater than the streamflow volume measured by the Swift River at West Ware USGS gage for every month, except April. The diversion of this water from Quabbin Reservoir to the Nashua and Connecticut River basins result in alterations to the timing and magnitude of flows within the Swift River watershed. This is particularly evident during the spring, when excess runoff is used to replenish the level of Quabbin Reservoir. For the period of record, April streamflow, on a per unit drainage area basis, in the Swift River watershed is approximately 25-30 percent of the Ware and Quaboag River totals, which are less influenced by withdrawals and diversion. Moreover, in the beginning of 2001, average monthly streamflow in the Swift River was well below historic levels, ranging from 0.16 cfsm (historic level = 0.41 cfsm) in January to 0.47 cfsm (historic level = 0.94 cfsm) in May (Table 4.2-1).

Under certain circumstances, the storage of water in Quabbin Reservoir does have beneficial effects on the magnitude of flows in the Swift River. MWRA is required to release a minimum flow of 20 MGD (32 cfs) from Quabbin Reservoir to the Swift River. There are also additional release requirements, when flows in the Connecticut River drop below certain thresholds. The ability to provide water from storage was evident during October and November of 2001, when precipitation totals in the Chicopee basin were 30 percent of their normal values. During those months, flows on the Ware and Quaboag Rivers were approximately 15 percent and 30 percent, respectively, of their normal levels compared to the period of record. For the coincident period, flows on the Swift River were near normal historic levels. In addition, for the period of record, streamflow within the Ware, Swift, and Quaboag River watersheds are quite similar for the months of July-September, even though the Swift River watershed is more heavily impacted by withdrawals and diversions (Table 4.2-1).

Table 7-1: Comparison of Inter-Basin Transfers and Streamflow in the Swift River Watershed

Month	Total In-Basin Withdrawals (MGD)	Out-of-Basin Transfer (MGD)	In-Basin Transfer (MGD)	Net Change Resulting from Inter-Basin Transfer (MGD)	Average Monthly Streamflow (MGD)	Net Change to Average Monthly Streamflow Ratio
January	187	182	0.2	(182)	20.0	-911%
February	210	205	0.2	(204)	20.1	-1017%
March	86	81	0.2	(81)	21.8	-369%
April	40	36	137	101	36.8	275%
May	182	178	0.2	(178)	56.9	-313%
June	207	205	0.2	(205)	61.0	-336%
July	238	235	0.2	(235)	44.5	-528%
August	333	329	0.2	(329)	73.0	-450%
September	287	282	0.2	(282)	67.9	-416%
October	358	353	0.1	(353)	75.0	-470%
November	306	301	0.2	(301)	76.9	-391%
December	217	211	0.2	(211)	31.3	-674%

Table 7-2 illustrates monthly water withdrawals, inter-basin transfer volumes and recorded streamflow within these watersheds for 2001. The Ware and Quaboag River watersheds are impacted much less by

water withdrawals and diversions compared to the Swift River watershed. However, from September to November of 2001, out-of-basin transfers represented more than 20 percent of the average monthly streamflow in the Ware River watershed. This was partly driven by unusually low streamflow resulting from lower than normal precipitation totals.

Within the Quaboag River watershed, out-of-basin transfers do not alter streamflows. Based on 2001 data, in-basin water withdrawals seem to have a relatively minor impact on streamflows. However, due to the low precipitation conditions experienced in the latter portion of 2001, in-basin water withdrawals represented more than 13 percent of the average monthly streamflow for the months of August, September, and October.

Table 7-2: Comparison of Inter-Basin Transfers and Streamflow in the Ware and Quaboag River Watersheds

Month	Total In-Basin Withdrawals (MGD)	Out-of-Basin Transfer (MGD)	In-Basin Transfer (MGD)	Net Change Resulting from Inter-Basin Transfer (MGD)	Average Monthly Streamflow (MGD)	Net Change to Average Monthly Streamflow Ratio
Ware River Watershed						
January	2.6	-	0.1	0.1	117.6	0.1%
February	8.7	6.2	0.1	(6.1)	155.8	-3.9%
March	3.5	1.1	0.1	(1.0)	406.5	-0.2%
April	138.8	137	0	(136.9)	749.7	-18.3%
May	3.3	1.4	0.1	(1.3)	134.4	-0.9%
June	4.2	1.8	0.1	(1.7)	284.4	-0.6%
July	4.9	2.7	0.1	(2.5)	100.2	-2.5%
August	8.6	5.7	0.1	(5.6)	56.2	-10.0%
September	10.3	7.8	0.1	(7.6)	38.5	-19.9%
October	8.3	5.9	0.1	(5.8)	20.6	-28.4%
November	8.3	6.1	0.1	(6.0)	24.3	-24.5%
December	7.9	5.7	0.1	(5.5)	59.3	-9.3%
Quaboag River Watershed						
January	2.8	0	0	0	93.1	0.0%
February	3.0	0	0	0	119.6	0.0%
March	3.1	0	0	0	319.3	0.0%
April	3.5	0	0	0	639.2	0.0%
May	4.0	0	0	0	96.9	0.0%
June	4.1	0	0	0	126.7	0.0%
July	3.7	0	0	0	56.4	0.0%
August	3.7	0	0	0	28.1	0.0%
September	3.3	0	0	0	16.7	0.0%
October	3.1	0	0	0	24.7	0.0%
November	3.0	0	0	0	39.5	0.0%
December	2.8	0	0	0	44.5	0.0%

8 Conclusions

Of the 3 major watersheds (Swift, Ware, and Quaboag), streamflows in the Swift River watershed have been affected the most by water withdrawals and inter-basin transfers. The operation of Quabbin Reservoir significantly alters the timing and magnitude of streamflow in the Swift River. In 2001, the out-of-basin transfers of 217 MGD from Quabbin Reservoir were substantially greater than the streamflow volume measured in the Swift River.

This diversion of water from Quabbin Reservoir results in alterations to the timing and magnitude of flows within the Swift River watershed, which may result in adverse impacts to downstream aquatic biota. Alterations in flow are particularly evident during the typical spring high flow period, when flows are drastically reduced in the Swift River because of flood skimming and water storage operations at Quabbin. From January to March 2001 streamflow measured at the Swift River USGS gage was far below long-term average conditions and below that of nearby rivers as well, ranging from 0.16 cfsm to 0.18 cfsm. These values are significantly lower than default minimum flow values, such as those recommended by the U.S. Fish and Wildlife Service's New England Flow Policy, for this time of the year.

MWRA is required to release a minimum flow of 20 MGD (32 cfs) from Quabbin Reservoir to the Swift River. There are also additional release requirements, when flows in the Connecticut River drop below certain thresholds. This flow release has beneficial effects such as maintaining Swift River flows, during late summer/early fall of 2001, near normal regulated levels during extended periods of low precipitation. At the Ware and Quaboag Rivers, which do not benefit from summer/fall flow augmentation, streamflows are directly tied to the prevailing precipitation levels, and as a result were much lower than historic averages during the late summer/early fall of 2001.

The Ware River watershed is impacted much less by water withdrawals and diversions compared to the Swift River watershed. However, from September to November of 2001, out-of-basin transfers were moderately high relative to average monthly streamflow in the watershed. This was partly driven by unusually low streamflow resulting from lower than normal precipitation totals. No in-basin or out-of-basin transfers of water occur in the Quaboag River watershed. However, due to the low precipitation conditions, in-basin water withdrawals were marginally high compared to the average monthly streamflow during the late summer/early fall of 2001.

It is unclear whether the interaction between water withdrawals, streamflow patterns, and water movement is consistent from year to year, since the evaluation of water withdrawals within this study was focused on the year 2001, which represented somewhat atypical hydrologic conditions. 2001 experienced several months of sustained drought and overall annual precipitation levels were approximately 13 percent below normal. A longer study period would have been representative of more typical hydrologic conditions.

A definitive analysis of consumptive water use within the Chicopee River basin was not fully evaluated, since the study contained only a cursory review of NPDES wastewater discharges, as the study scope did not allow for an exhaustive data collection and evaluation effort.

9 Recommendations

The following recommendations to improve management of water movement and use are based on the conclusions of this study.

- Evaluate alternative schedules for minimum flow releases from Quabbin Reservoir to the Swift River to mimic natural flow patterns to the extent possible. The operation of Quabbin Reservoir significantly alters the timing and magnitude of streamflow in the Swift River. It may be possible to minimize the potential impact of these water withdrawals on downstream aquatic biota through alternative reservoir management practices.

- Future investigations should encompass a five year evaluation period of the interaction between water withdrawals, streamflow patterns, and the corresponding movement of water within the Chicopee basin. The evaluation of water withdrawals within this study was focused on the year 2001, which represented atypically dry hydrologic conditions. A longer study period would be more representative of average hydrologic conditions.

- Future investigations should include a more detailed inflow/outflow analysis to assess monthly water balances within each watershed. The study examined water withdrawal volumes in detail; however, limitations in the scope did not allow for an in-depth analysis of consumptive water use in the Chicopee basin.

- The interactive Geographic Information System (GIS) should be updated periodically with new data as it becomes available. A significant portion of this study included the development of an interactive GIS, which contained the data collected as part of this study. It is envisioned that the GIS will assist those, who manage the water resources within the Chicopee River basin, as well as those who wish to understand water movement and use in the basin.

10 References

Massachusetts Department of Environmental Management (MDEM), Comprehensive Watershed Assessment Report, 2002.

Massachusetts Department of Environmental Protection (MDEP), Chicopee River Watershed Water Quality Assessment Report, 1998.

United States Geological Survey (USGS), Water Resources Homepage, Obtained from website: http://waterdata.usgs.gov/ma/nwis/uv?01101000, 2003.